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**FOUR DECADES OF CAUSE-SPECIFIC MORTALITY
IN THE CZECH REPUBLIC, WEST GERMANY
AND FRANCE**

Dissertation thesis

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I hereby declare that this dissertation is completely my own work and that I used only the cited sources. This dissertation thesis or any of its parts have not been submitted to obtain other or identical academic degree.

In Prague, may 2010

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Abstrakt

Cílem práce je zhodnocení vývoje úmrtnosti podle příčin v České republice, Německu (bývalé SRN) a Francii za uplynulých čtyřicet let. Základním problémem demografického studia úmrtnosti podle příčin je dostupnost a srovnatelnost dat, a to jak v čase tak mezi jednotlivými zeměmi. Časová srovnatelnost je narušována pravidelnými revizemi mezinárodní klasifikace nemocí (MKN), zatímco srovnatelnost v mezinárodním měřítku je ztěžována různými interpretacemi této klasifikace v jednotlivých zemích. První (a převážná) část práce je proto věnována procesu rekonstrukce časově srovnatelných řad úmrtnosti podle příčin v Německu a v České Republice. V druhé části jsou poté tato získaná data porovnána s již existujícími dlouhodobými řadami pro Francii. Z výsledků vyplývá, že takto zpracovaná data poskytují velmi solidní základ pro analýzu příčinných podmínek úmrtnosti a nacházejí tak širší uplatnění ve studiu teorie epidemiologického (nebo nověji zdravotního) přechodu.

Klíčová slova: úmrtnost, příčiny úmrtí, MKN, Česká republika, SRN, Francie

Four decades of cause-specific mortality in the Czech Republic, West Germany and France

Abstract

The study aims at analysis of cause-specific mortality trends in the Czech Republic, Germany (former FRG) and France over the past four decades. The major issue in the demographic study of cause-specific mortality is availability and international comparability of the data in a long-term. The backward comparability is affected by regular revisions of the international classification of diseases (ICD), while the comparability between countries suffers mainly from its divergent interpretations. The first (and main) part of the work therefore focuses at the process of reconstruction of continuous time series of mortality by cause of death in West Germany and in the Czech Republic. In the second part the obtained series are compared to the existing data for France. The results suggest that when carefully processed data are used, they provide solid base for analysis of the underlying cause-specific factors of mortality changes, and can therefore, in a broader context, be used in the evaluation of the theory of epidemiological (or more recently health) transition.

Key words: mortality, causes of death, ICD, Czech Republic, West Germany, France

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List of acronyms

ACME	Automated Coding of Medical Entities
AIDS	Acquired Immune Deficiency Syndrome
AMI	Acute Myocardial Infarction
APHA	American Public Health Association
ARC	AIDS-related complex
BTL	Basic Tabulation List
CA	Cancer
CDC	Centres for Disease Control
CM	Clinical Modification
COD	Cause of Death
COPD	Chronic Obstructive Pulmonary Disease
CSO	Czech Statistical Office
CVD	Cardiovascular Diseases
CZE	Czech Republic
ČSÚ	Český statistický úřad
DIMDI	Deutsche Institut für Medizinische Dokumentation und Information
EU	European Union
FIC	Family of International Classifications
FRA	France
GER	West Germany
HDC	Heart disease complex
HIV	Human immunodeficiency virus
HMD	Human Mortality Database
HP	Hyperplasia
ICD	International Classification of Diseases
IHD	Ischemic Heart Disease
IHO	Imperial Health Office
INED	Institut National d'Etudes Démographiques
INSEE	Institut National de la Statistique et des Etudes Economiques
INSERM	Institut National de la Santé et de la Recherche Médicale
ISI	International Statistical Institute
LEB	Life Expectancy at Birth
MICAR	Mortality Medical Indexing, Classification, and Retrieval
MRSA	Methicilin-Resistant Staphylococcus Aureus
MSE	Mortalité, Santé, Epidémiologie
NCHS	National Center for Health Statistics
PTCA	Percutaneous Transluminal Coronary Angioplasty
RR	Relative Risk
SD	Standard Deviation
SDR	Standardized Death Rate
SIDS	Sudden Infant Death Syndrome

SNOMED	Systematized NOMenclature of MEDicine
STD	Sexually Transmitted Diseases
TBC	Tuberculosis
ÚZIS	Ústav Zdravotnických Informací a Statistiky
WHO	World Health Organization
WWI	World War I
WWII	World War II

Introduction

For long time in the past, the human life expectancy was not more than 30 years. Its length began to extend systematically along with global societal transformation processes in the 19th century. Altogether with decreases in fertility, this process took place in all industrialized countries and has later been formalized as a theory of demographic transition. Regarding mortality, the earliest determinants of these remarkable improvements were advances in nutrition and sanitation, while further mortality decline has been underlied by major advances in medical science, notably the discovery of infectious origin of diseases.

In 1971, Abdel Omran summarized what was known at that time about the epidemiology of population change, and postulated the *theory of epidemiologic transition* (Omran 1971). In his view, the transition consisted of three “ages”. In the earliest times prior to the demographic transition, mortality as well its fluctuations was strong (age of pestilence and famine). In the next age (of receding pandemics), the pandemics, famine and wars cede their place to endemic infections, less fluctuant and steadily declining (mostly tuberculosis and diarrhoea). In the last – third – age, the degenerative and man-made diseases take over the epidemiologic profile. Based on the trends observed in the 1960s, which have seen a sensible slow-down of mortality progress due to stagnation or even increase in cardiovascular mortality, he predicted a stabilization of mortality at these achieved levels.

Since the 1970s however, a further unanticipated decline of death rates was observed, which lead in 1987 to the extension of the theory by a fourth age – age of delayed degenerative diseases (Olshansky and Ault 1986).

The nature of these unprecedented declines of cardiovascular mortality was found too inconsistent with the epidemiologic transition theory and finally lead to its reassessment and postulation of a more global concept of health transition (Frenk et al. 1991). In the health transition theory, the ages described by Omran are considered as the first stage, characterized by external conditionality of mortality decline – depending, in a broad summary, on the quality and

availability of information, sanitation and medicine. For the successful second stage, which begins with the *cardiovascular revolution*, apart from medical advances much more individual responsibility with respect to individual's own health is needed (Meslé and Vallin 2002).

In the European context, the first stage of health transition has been achieved in the yearly post-war years, and resulted in a general convergence of mortality – the smallest differences between life expectancy at birth were observed around 1965 (Vallin and Meslé 2004). After a critical decade of the 1960s, the mortality trajectories divided again, with respect to the progress in cardiovascular mortality: in countries of Eastern Europe the levels stabilized or even decreased under those observed by the late 1960s. To a lesser extent however, divergences were observed also among Western countries.

Any evaluation of changes in epidemiologic profiles requires, at first, detailed, long-term and reliable cause-specific data. Unfortunately, there are three obstacles to the use of these data: revisions of the disease classification, changes in cause-of-death coding, and – finally – varying proportions of deaths with unknown or poorly defined cause.

The International Classification of Diseases and Related Health Problems (ICD), the main tool for coding and tabulating data on causes of death, is periodically revised to reflect progress of medical knowledge. Consequently, with every new revision, the time series of mortality by cause of death are interrupted.

National statistical offices rarely produce a double classification (cross-tabulation of deaths by both the actual and the previous revision) that would make it possible to directly redistribute the deaths of the previous periods according to the new classification. Such an attempt was made for England and Wales, for example, with the transition between ICD8 and ICD9 (OPCS 1983). Nevertheless, the transition coefficients derived from the English double classification could not be applied to other countries, because coding practices vary from country to country (Meslé and Vallin 1993).

Due to the difficulties related to ICD revisions and differences in coding habits, the cause-of-death data are often underexplored: studies limited their time-range to the duration of one ICD revision, or use simplistic aggregation into broad groups of causes. A method to reclassify the causes of death *ex post* when double-coding information is missing was developed and later applied in many countries, including France (Vallin and Meslé 1988), Russia (Meslé et al. 1996), Ukraine (Meslé and Vallin 2003), and the Baltic countries. Long-term time series also exist for the Netherlands (Wolleswinkel-van Den Bosch et al. 1996).

The thesis aims to focus at cause-specific components of mortality trends in Czech Republic, West Germany and France after 1968. In the frame of the doctoral studies, the author participated in a project entitled Mortality in Germany¹. One of the project research questions was comparing the cause-specific mortality trends in West and East Germany before and after the reunification. The author's task related to the reconstruction of detailed time series covering the 8th and the 9th revision of ICD for the territory of West Germany. Later on, to allow for comparison between West Germany and the country of author's origin, the same method has been applied to the Czech Republic. Finally, France was selected because it has the longest, the

¹ A project of Max Planck Institute for Demographic Research, Rostock

most detailed, and the best documented cause-of-death data time series (starting as early as from 1925).

Major novelty of this thesis therefore is the production of long-term time series of mortality by cause of death in the West Germany and the Czech Republic. In the case of West Germany, the data have already been published and made available on-line for further demographic research.²

Another novelty aspect of the presented work is the inclusion of the current 10th revision of ICD. The ICD10 represents a recent challenge in cause-of-death studies: it establishes a new tabulation system and a new set of coding rules, and has ambitions to become a “stable and flexible classification which would not require revisions for many years to come” (WHO 1993). Bridging the current (10th) and the previous ICD revisions thus deserves close attention. Finally, for the first time, long-term cause-specific data at such level of detail stand aside for direct international comparison.

Outline

The first chapter introduces the reader into the theory of the nomenclature and statistical classification of diseases, and outlines its history from early roots to contemporary concepts and future insights.

Routine mortality statistics usually tabulate one cause of death, while majority of the deceased persons, especially at old ages, suffer from multiple diseases. The international rules for selection of the cause which will appear in the final statistics are explained in the second part of this chapter.

While the classification and the coding rules are international, statistical systems in each country collect and process the cause-of-death information in their proper way and as such may impact the quality of the cause-of-death data. The origins and the specifics of the data collection in the three countries of our interest are therefore outlined in chapter 2.

The third and the fourth chapters describe how the continuous time series by cause-of-death were obtained. The core of the work, transition between the 8th and the 9th revision of ICD performed at detailed level in two countries, is presented in chapter 3, starting from explanation of the applied methodology and giving concrete examples of solutions to particular issues encountered at different stages of work at the German Czech data.

The fourth chapter is then dedicated to the recent ICD revision. The first part discusses experiences with impact of ICD10 adoption in countries, where it has been evaluating via specialized double-coding studies. In the next step, an abridged multi-purpose list of 186 items is proposed with respect to allow for smooth transition between the reconstructed time series while keeping maximum of explanatory information. As for the previous transitions, specific cases and their treatment are discussed.

Before proceeding to the analytical part, the full range of reconstructed causes of death is inspected for potential issues in comparability using graphical representation of mortality trends since the 1968 by country and sex. This chapter also serves as basis for extraction of the

^{2 2} Annex with data: http://www.demogr.mpg.de/publications/files/2969_1203347723_1_Annex/

“analytical” list - a mixture of diseases believed to be comparable, reliable and valuable source of information, and some diseases of non-specific profile which play different role in each country.

The final chapter then examines the interactions between causes of death and the overall mortality in the time perspective of forty years. The first part introduces the trends observed for all-cause mortality and its variations by country, age and sex. These findings are then connected to cause-specific information via the application of multiple decrement life tables, with 27 selected causes of death as decrements. This approach enables to evaluate how the competition between diseases and shifting cause-specific age profiles interact with overall life expectancy at birth.

Chapter I.

The past, the present and the future of ICD

The question of how to classify the diseases for statistical purposes is as old as the collection of the data itself. In the first period of modern statistics (i.e. right after the establishment of systematic vital event registration) the classifications of causes of death were in the competence of respective administrative authorities and usually comprised simple short lists of the most frequent epidemic diseases and accidents. This has changed with the new advances of nosology and statistics in the 19th century. In 1853 the first international statistical body was founded and at this point starts the history of the classification of diseases as we know it nowadays under the initials ICD used for International Classification of Diseases.

The first part of this chapter traces the history of ICD from its very origins to the future – 11th – revision. In the course of time, in order to assure maximum comparability on an international scale, the ICD also incorporated recommendations and rules for the collection and tabulation of causes of death. These recommendations are subject of the second part of this chapter. Material for this section was mainly extracted from three exhaustive sources of information: the ICD manual itself (WHO 1992), the book dealing with cause-of-death time series in France by Vallin and Meslé (Vallin and Meslé 1988), and the essay on the history of medical classifications by Fagot-Largeault (Fagot-Largeault 1998).

2.1 The modern history of medical classifications

The scientific study of causes of death dates back to the 17th century. In his *Observations on the London bills of mortality*, John Graunt (considered as founder of modern demography and

epidemiology) estimated the mortality structure by age based on the structure of causes of death classified into an alphabetically ordered list of cca 80 items (Graunt 1665).³

In current terminology, the „Graunt’s“ list comprised the main infectious and parasitic diseases (ague/fever, consumption [TBC], flox, small pox, purples, jaundice, leprosy, measles, plague, ricketts, spotted fever, swine pox, worms), followed by other diseases known at that time (cancer, gout). Several items of the list related directly to the age of the dead person (abortive and stillborn, chrisoms, overlaid, aged) and distinction was made between natural and non-natural deaths, providing several categories of accidental mortality: burnt, drowned, hanged and made-away themselves, killed by accidents, murdered, smothered, poisoned, executed. Major part of the list, however, consisted of what today would be designated as symptoms and ill-defined causes, like bleeding, convulsions, vomiting, dropsy, head-ache, dysentery, sudden death, senility, etc.

Obviously, such list reflects the state of medical knowledge of that time, and, due to its non-conceptuality, it cannot either be considered a classification. Eventually, the list was not even based on a clear nomenclature, and Graunt himself wondered about the actual meaning of the reported diagnoses and discusses their reliability. His intuitive analysis however revealed some of the questions that until present remain up-to-date.

Later on, encouraged by the success of Graunt’s theses, and nourished by the persisting need to enumerate the epidemic population losses, increasing number of countries recognize the advantages of systematic mortality data recording. However, a century had to pass since Graunt’s fundamental work for the first attempts of a systematic cause-of-death classification to appear. These attempts include the classifications of Sauvages (Montpellier), Linné (Upsala), Vogel (Gottingen), Cullen (Edinburgh), Brown (London), and Pinel (Paris), to cite a few, out of which the classification of Sauvages (Boissier de Lacroix) is the oldest, dating from 1730, the one that inspired Linné for his *Generum Morborum*.

Since the very beginning, disputes have existed about the logic to be employed in the cause-of-death classification, which resulted in the coexistence of several classification axes: anatomic (by the site affected), physiologic (by the function affected), etiologic (by the origin of the disease) and symptomatic (by the manifestation of the disease) (Fagot-Largeault 1998), without speaking of the status of the person (age, sex, pregnancy, etc.). Moreover, hand in hand with the discussion on the classification theoretical principles, there has always been the conflict between its medical correctness, its statistical applicability and the changing state of medical knowledge.

An important contribution to the history of the disease classification came from William Farr (1807–1883), the first statistician of the General Register Office of England and Wales as of 1837. Farr, physician fascinated by epidemiology and medical statistics, lobbied for an improved nomenclature and classification in the annual reports to the Registrar general: *„The advantages of a uniform statistical nomenclature, however imperfect, are so obvious, that it is*

³ Around that time, the cause of death was thus considered somewhat more relevant than the age. The reason to primarily collect the cause of death had originated, most likely, from the need to enumerate the victims of the big seasonal epidemics, out of which the plague held the privileged position for a long time.

*surprising no attention has been paid to its enforcement in Bills of Mortality. Each disease has, in many instances, been denoted by three or four terms, and each term has been applied to as many different diseases: vague, inconvenient names have been employed, or complications have been registered instead of primary diseases. The nomenclature is of as much importance in this department of inquiry as weights and measures in the physical sciences, and should be settled without delay.”*⁴

Farr was well aware of the fact that the statistical science cannot wait for medicine to propose the ultimately correct classification and that, necessarily; the medical classification has to represent a **pragmatic compromise** adapted to the needs of the public health.

2.1.1 The first attempts of international classification

The registration and the use of demographic data rapidly increased during the 19th and early 20th century. Countries began to institutionalize the nation-wide obligation to collect cause-of-death data (in United Kingdom in 1837 after the 1836s Registration Act, in France and Germany later in 1906, to cite a few.)⁵

The existing amounts of internationally incomparable data were one of the concerns discussed at the first International Statistical Congress, held in Bruxelles in 1853. As England and Geneva were among the rare regions to collect medical causes of death, their medical statisticians William Farr and Marc d'Espine were asked to prepare the list of categories for what should have become the future international classification of causes of death. Unfortunately, Farr and d'Espine worked separately, and for the next congress (Paris, 1855) they brought back two different classification concepts. The classification of d'Espine was a list based on the nature of the disease (primarily acute / chronic disease progression). Farr employed a more pragmatic classification scheme distinguishing epidemic and constitutional diseases while leaving space for a large category of diseases which were well-known and localized, but etiologically unclassified (assuming that in the actual state of medical knowledge, the science can already profit even from a purely symptomatic classification, as long as this one can precisely determine the relative frequency of inflammations, tuberculosis, cancer, etc. and to reveal their background, thus helping to prevent them) (Fagot-Largeault 1998). One of the main reproaches to the etiologic classification principle was that as medicine evolves, the diseases become well identified and described, but their etiology is clarified much later and the path to the correct explanation is usually not straightforward. Adopting the etiologic principle would thus inevitably lead to numerous misclassifications and need frequent updates.⁶ Basic pattern of the two proposals was the following:

Farr:

- *Epidemic diseases*
- *Constitutional or general diseases*

⁴ W. Farr, “Letter to the Registrar General”, in: *First Annual Report to the Registrar General*, London HMSO. 1839, p. 99.

⁵ The years refer to the nation-wide collection of the cause-of-death data; in big cities the data were collected much earlier.

⁶ Laennec, R. *Traité d’auscultation médiate*. Paris 1819 (cit. in (Fagot-Largeault 1998))

- *Local diseases arranged by site*
- *Developmental diseases*
- *Injuries*

D'Espine:

- *Still-born*
- *Congenital malformation*
- *Senility*
- *Violent death or external accident*
- *Deadly accident*
- *Acute diseases*
- *Chronic diseases*
- *Unknown cause of death*

Eventually, the congress of 1855 adopted a sort of compromise between these two principles. The majority of items (97 out of 139) belonged, however, to the group designated as „well-known diseases“ without a more refined classification:

- *Still-born*
- *Congenital debility*
- *Senility*
- *External accident or violent death*
- *Well-known diseases*
- *Ill-defined diseases or symptoms*
- *Unknown cause of death*

This first international classification was never adopted by any country.⁷ Later in 1864 the classification was revised to comply more with the model proposed by Farr. Next revisions were made in 1874, 1880 and 1886, but the use of the classification remained null – countries continued using their proper systems.

2.1.2 Origins of the International classification of diseases

The authorship of what today is known as ICD is usually attributed to Jacques Bertillon (1851-1922). Bertillon, head of Statistical Services of the City of Paris as of 1883, had already systematically prepared a classification for the city of Paris (in use since 1886). Naturally, the third reunion of the International Statistical Institute (ISI)⁸ in Vienna (1891) charged Bertillon to prepare the new concept of the future international classification of diseases.

In 1893 in Chicago, Bertillon presented three nested classifications of 44, 99 and 161 items⁹, derived from the classifications of Paris, Geneva and Berlin and primarily based on the

⁷ According to Kintner, the classification was however used in Hesse (Kintner 1999)

⁸ Founded in London in 1885

⁹ Some items included subdivision, the total number of items was thus 203.

anatomic localisation of disease (inspired by Farr's local diseases arranged by site). The structure by chapter was the following:

Bertillon 1893:

- *General diseases*
- *Diseases of the nervous system and sense organs*
- *Diseases of the circulatory system*
- *Diseases of the respiratory system*
- *Diseases of the digestive system*
- *Diseases of the genitourinary tract and annexa*
- *Puerperal diseases*
- *Diseases of the integumentary system*
- *Diseases of the organs of locomotion*
- *Malformation*
- *Diseases of infancy*
- *Diseases of old age*
- *External causes*
- *Ill-defined causes*

The classification was accepted by the ISI and, unlike for the classification of 1855, it was immediately adopted in several countries and cities. There were several reasons for this relative success of the "Bertillon classification", as it was originally called. First, as Vallin and Meslé (1988) claim, at that time, enough evidence had already been brought by the medicine to allow for a general acceptance of (some) medical facts. Second, the classification was better adapted to the needs of statistics and public health. The third contributing factor possibly was the efficient "marketing strategy": Bertillon addressed himself to the majority of statistical offices, proposing the use of his classification, plus the classification was also largely supported by the American Public Health Association (APHA), which recommended its use in the three North-American states as of 1900, to enable: "*the mortality statistics of the next century to be begun on a uniform basis*" (Wilbur 1898).

In spite of the general approval of the Bertillon system, there has also been criticism on the classification logic and principles. It was reproached to him that, unlike stated, his scheme is not purely based on disease localization (more precisely, the chapters of general diseases, malformations, age-related diseases and external accidents are not) and that such division into the mixed groups leads to confusing results ("*thus we find typhoid fever, diabetes and gout in the first group, tetanus, cretinism, cataract in the second, and pneumonia and polyps of the nasal cavity in the fourth.*" (Winslow 1900) Furthermore, the sense of the whole category of general diseases was impeached: "*It is, perhaps, to be expected that cerebro-spinal meningitis should be classed as a disease of the nervous system, but to find peritonitis under diseases of the digestive system and puerperal septicaemia as a disease of puerperium make one wonder just what a 'general disease' may be.*" (Winslow 1900)

Bertillon's defence of the criticism was that 1) the disease site is always easier to determine than the disease origin and that 2) strict etiology-based classification will not stand the test of time, making the time series incompatible with the future classifications. Bertillon keeps in mind that "*theories change, morbid entities remain*", as was claimed at the international statistical congress of the 1855 (Fagot-Largeault 1998).

2.1.3 Staying abreast with medical progress

When the APHA accepted to use the Bertillon classification, it also proposed its regular decennial revisions to stay abreast with the progress of medical science. The request was found meaningful during the first International Conference for the Revision of the Bertillon (or International) List of Causes of Death in 1900 in Paris and the process of the classification updates, which continues to present days, has begun. With time, the classification of causes of death became the classification of diseases, including also non-fatal conditions.

First revision (1900)

At the first updating reunion, discussions arose on the purpose of the class of senility and on the problem of multiple causes registered on the death certificates. It was also decided to drop the semi-abridged list of 99 causes and to make several minor adjustments to the classification, which, by their nature, antagonized the Bertillon's doctrine of anatomic localization of the diseases.¹⁰

Second revision (1909)

The next updating reunion was called by the French Ministry of Foreign Affairs for the year 1909.¹¹ The joint causes (multiple causes) were re-discussed. The slightly revised classification now contains 189 items and the tendency continues to accumulate causes of death in the first chapter of general diseases.

Third revision (1920)

Bertillon was always strictly opposed to the idea of splitting the first chapter of general diseases, in order to avoid numerous reclassifications of e.g. parasitic diseases, which he considered well placed by their anatomic localization (Fagot-Largeault 1998). Nevertheless, after the explosion of microbiological discoveries, this doctrine proved unsustainable and the third revision split the first chapter into epidemic, endemic and infectious diseases and the rest (including cancer, rheumatism, diabetes, anaemias, poisonings and many other various diseases). Bertillon dies two years later in 1922.

¹⁰ Several infectious diseases are retrieved from the organ-related chapter and placed under general diseases; the tendency appears to group cancers together, etc. (see Vallin and Meslé 1988 for comprehensive list).

¹¹ Until his death in 1922 Bertillon was in charge of the classification updates and diffusion.

Fourth revision (1929)

After Bertillon's death, France remains responsible for the classification maintenance, but with greater involvement of the emerging international structures headed by the League of Nations' Health Organization. The proposals for the fourth (1929) and the fifth (1938) revisions of the International List of Causes of Death were prepared by the "Mixed Commission" of representatives from the International Statistical Institute and the Health Organization, but both reunions still took place in Paris. The classification also started to have ambitions to be used for the purposes of the international morbidity study, and Dr. Roesle, Chief of the Medical Statistical Service of the German Health Bureau and a member of the Commission of Expert Statisticians, carefully outlined its necessary extension.

Another innovation was a return of the intermediate list of 85 items, along with a detailed 200 items list and an abridged list of 43 items. In 1934, between the fourth and the fifth revision, more than 20 countries signed the "International Agreement relating to Statistics of Causes of Death", a consensus to publish comparable statistics based on the intermediate international list of 85 causes.

The biggest innovation in the classification structure was another subdivision of general diseases into cancer (chapter II), rheumatic, nutritive, endocrine and other general diseases (chapter III), diseases of blood and blood-forming organs (chapter IV) and chronic poisoning and intoxication (chapter V). Except for chapter III, all these changes followed the etiological classification logic.

Fifth revision (1938)

The chapter structure went unchanged by the fifth revision. However, several etiological adjustments continued within the individual chapters. In that direction, infectious and parasitic diseases were sub-divided according to the nature of the etiological agents (bacterial, dysenteric, protozoal, spirochetal, viral, rickettsial, helminthic and fungal), and in chapter II the avitaminoses were grouped together. To better isolate the effect of alcohol, important for the public health analysis, the alcoholic pellagra joins the alcoholic dependence. At the end of the classification, a bigger detail is given to the transport accidents (by transportation means), while the detail for the means of suicides is limited (however, remains as subdivision).¹²

The fifth conference retained the idea of an intermediate list and approved three lists: a detailed list of 200 titles, an intermediate list of 87 titles and an abridged list of 44 titles. Not evident at first sight, although considered essential by some authors, is the enormous increase of the classification detail by the inclusion of numerous subdivisions (Vallin and Meslé 1988). In fact, the total number of items, all levels counted, reaches 452 in the fifth revision. Such tendency reflected the incredible progress of medical knowledge on one hand, and was equally a result of the preparation to the multiple (primarily morbidity) use of the classification, pronounced already in the efforts of Dr. Roesle. It also predicted the unavoidable future transformation of what was still called „nomenclature“ in French or „list“ of causes of death in

¹² The reason why the expansion of the detail for some causes was compensated by the loss of detail elsewhere is that the revision of 1938 was a priori limited by the given total number of items, set to 200.

English, into a sheer statistical classification of diseases. However, the international list, even in its extended form, never received a general acceptance for morbidity statistics. Instead, several country-specific morbidity classifications were elaborated and used: a *Standard Morbidity Code* in Canada (1936), *A provisional classification of diseases and injuries for use in compiling morbidity statistics* in United Kingdom (1944), the *Manual for coding of causes of illness according to a diagnosis code for tabulating morbidity statistics* in the United States (1944) and the *Morbidity Code* in France (1945).

The fifth revision also appointed United States to pursue their research on the increasingly acute question of selection of the principal cause of death among multiple causes present on the death certificate.

Creation of WHO and its role in the development of ICD

The period of the fourth and fifth revision was marked by gradual transformation of the Bertillon's classification conception into the international and interdisciplinary cooperation and consensus, always marked by constant dilemma between the classification stability (practical continuity) and movement (adaptation to medical progress). By the end of the period, the Bertillon's original anatomic conception was replaced by an etiological criterion where the medical knowledge allowed for it. With the increasing use of the international list, two major concerns emerged: the parallel classification of non-fatal condition suitable both for morbidity and hospital statistics, and the selection of a single major cause among multiple reported causes. Their solution was however to be found only after the WWII, with the arrival of the "new era" of the international classification of diseases.

In July 1945, the World Health Organization was created as the health organization of the United Nations, the successor of the League of Nations. The International Health Conference held in New York City the next year, 1946, created the Interim Commission of the World Health Organization, the future responsible of preparing the next decennial revision of the international list and a new nomenclature of diseases.

Sixth revision (1948)

The Expert Committee, appointed by the WHO Interim Commission, based its work on the pre-existing classification of the United States Committee on Joint Causes of Death¹³ and presented the document entitled provisionally as *International Classification of Diseases, Injuries, and Causes of Death* to 72 countries for review and suggestions. The committee also prepared a list of inclusions for each classification title and an alphabetical index of diagnostic statements.

This classification proposal was then presented and approved at the International Conference for the Sixth Revision of the International Lists of Diseases and Causes of Death,

¹³ In 1945, a United States Committee on Joint Causes of Death was established. It recognized the advantages of a single classification for mortality and morbidity coding, and appointed a subcommittee to prepare *Proposed Statistical Classification of Diseases, Injuries and Causes of Death*.

convened once again in Paris in April 1948. For several reasons, the sixth revision is considered a milestone in the world mortality statistics:

- a comprehensive classification was adopted for morbidity and mortality, accompanied by an unprecedented increase of the classification detail;
- the international form of death certificate became an integral part of the classification;
- the underlying cause of death was defined and recommended as a single cause to be tabulated;
- the rules for selection the underlying cause of death became integral part of the classification;
- guidelines were provided for standardization of data collection.

Due to inclusion of non-fatal conditions, the first WHO-based classification contained 765 items designated by the 3 digit codes (001 to 999). Some items were sub-divided using a 4th digit and the total number of categories thus reached 2001 (compared to 452 in the previous revision). Another important innovation introduced by WHO lies in the double classification of accidents either according to its external cause (E-classification) or the nature of lesion (N-classification). While the E-classification is integral to the ICD, the N-classification brings other 169 (1611) 3-digit (4-digit) items to the classification.

Compared to the general radical character of the changes introduced by the 6th revision, the structure by main chapters remains relatively unchanged. In the new era, the ICD thus remains a variable-axis classification (etiology/anatomy/onset circumstances), in which the original ideas of Farr are still noticeable. What have changed considerably were the definitions of individual diseases and their position in the new classification. The high complexity of the change between the 5th and the 6th revision was demonstrated by Vallin and Meslé (1988), who attempted to reconstruct the cause-of-death series for France from 1925. Their conclusion is based on the fact that most of the deaths (85%) from the two transition years were gathered in a few (14) elementary associations of ICD5 and ICD6 items.¹⁴ The authors also doubt about the existence of a general idea driving the changes brought by ICD6. On one hand, several changes are made with respect to the new advances in etiology (especially in favour of the infectious diseases). On the other hand, influenza, classified under infectious diseases in the 5th revision of the international list (item 33) joined the chapter of respiratory diseases (items 480-483). By the same token, rheumatic fever (an inflammatory disease that may develop after an untreated streptococcal infection, often affecting heart valves) was placed along with cardiovascular diseases (400-402), while other rheumatism went to the chapter of musculoskeletal diseases (720-727).

Another important innovation of the 6th revision was the creation of the chapter of mental disorders (chapter V), and the placement of senility, previously forming a separate chapter, under the chapter of ill-defined disease (chapter XVI). The structure of the chapters introduced by the 6th revision of the international classification persisted relatively unchanged until present:

¹⁴ Elementary associations are the smallest possible clusters of the items of two successive ICD revisions with the same medical content. We will come back to the concept of elementary association later in chapter IV.

- I. Infective and parasitic diseases (001-138)*
- II. Neoplasms (140-239)*
- III. Allergic, endocrine system, metabolic and nutritional diseases (240-289)*
- IV. Diseases of the blood and blood forming organs (290-299)*
- V. Mental, psychoneurotic, and personality disorders (300-326)*
- VI. Diseases of the nervous system and sense organs (330-398)*
- VII. Diseases of the circulatory system (400-468)*
- VIII. Diseases of the respiratory system (470-527)*
- VIX. Diseases of the digestive system (530-587)*
- X. Diseases of the genito-urinary system (590-637)*
- XI. Deliveries and complications of pregnancy, childbirth, and the puerperium (640-689)*
- XII. Diseases of the skin and cellular tissue (690-716)*
- XIII. Diseases of the bones and organs of movement (720-749)*
- XIV. Congenital malformations (750-759)*
- XV. Certain diseases of early infancy (760-776)*
- XVI. Symptoms, senility and ill-defined conditions (780-795)*
- XVII. External causes of accidents, poisonings, and violence (E800-E999)*

Seventh revision (1955)

Only seven years after the first WHO-based revision, the classification was revised during the International Conference for the Seventh Revision of the International Classification of Diseases held in Paris in February 1955. The 7th revision was possibly the smallest in the history of ICD, limited essentially to amendments of errors. 80% of titles went unchanged, and the remaining 20% consisted mainly of changes in format or definition of the titles.

Eighth revision (1965)

The eighth revision of the ICD, adopted in Geneva in 1965, incorporated numerous suggestions gathered since 1948. As a result, the classification changed considerably again. The nomenclature of ICD, represented by the alphabetical index, was largely updated by introducing new diagnostic entities and deleting old-fashioned medical expressions. At the 3-digit level, the classification detail rose from 765 to 862 titles. The refinement of detail was even more pronounced at the level of the 4th digit, where the number of items increased by more than 30% (from 2124 to 2785). The basic structure by chapter remained unchanged, but the names of the main chapters were slightly modified. The main modifications are:

- chapter III “lost” the allergic diseases
- chapter V title was simplified from Mental, psychoneurotic, and personality disorders to Mental disorders
- chapter XIV entitled congenital malformations in ICD7 became congenital anomalies

- chapter XV was enriched by the causes of mortinatality (previously subject of a supplementary Y-classification). The notion of “perinatal period” thus replaced “early infancy”.
- notion of senility was definitely dropped from the title of the ill-defined causes (chapter XVI), which now becomes Symptoms, signs and ill-defined conditions¹⁵

Table 1 compares the main chapters of ICD7 and ICD8.

Table 1 List of ICD7 and ICD8 chapters

ICD7			ICD8		
Chapter	Codes	Title	Chapter	Codes	Title
I	001-138	Infective and parasitic diseases	I	001-136	Infectious and parasitic diseases
II	140-239	Neoplasms	II	140-239	Neoplasms
III	240-289	Allergic, endocrine system, metabolic and nutritional diseases	III	240-279	Endocrine, nutritional and metabolic diseases, and immunity disorders
IV	290-299	Diseases of the blood and blood forming organs	IV	280-289	Diseases of the blood and blood-forming organs
V	300-326	Mental, psychoneurotic, and personality disorders	V	290-319	Mental disorders
VI	330-398	Diseases of the nervous system and sense organs	VI	320-389	Diseases of the nervous system and sense organs
VII	400-468	Diseases of the circulatory system	VII	390-458	Diseases of the circulatory system
VIII	470-527	Diseases of the respiratory system	VIII	460-519	Diseases of the respiratory system
IX	530-587	Diseases of the digestive system	IX	520-577	Diseases of the gastro-intestinal system
X	590-637	Diseases of the genito-urinary system	X	580-629	Diseases of the genito-urinary system
XI	640-689	Deliveries and complications of pregnancy, childbirth, and the puerperium	XI	630-676	Complications of pregnancy, childbirth, and the puerperium
XII	690-716	Diseases of the skin and cellular tissue	XII	680-709	Diseases of the skin and subcutaneous tissue
XIII	720-749	Diseases of the bones and organs of movement	XIII	710-738	Diseases of the musculoskeletal system and connective tissue
XIV	750-759	Congenital malformations	XIV	740-759	Congenital anomalies
XV	760-776	Certain diseases of early infancy	XV	760-779	Certain conditions originating in the perinatal period
XVI	780-795	Symptoms, senility and ill-defined conditions	XVI	780-796	Symptoms, signs and ill-defined conditions
XVII	E800-E899	External causes of accidents, poisonings, and violence	XVII	E800-E999	Accidents, poisonings, and violence, external causes
	N800-N999	Supplementary classification of Injury and poisoning		N800-N999	Supplementary classification of Injury and poisoning

In the terms of death counts, the most important innovation brought by the 8th revision, is the removal of the *Vascular lesions affecting central nervous system* (ICD7 items 330-334) from the Diseases of the nervous system and sense organs (Chapter VI) and their placement under the sub-section of cerebrovascular diseases of the ICD8 chapter of cardiovascular diseases.

On the topic of the classification principle the WHO ICD10 manual states that: “This revision [the eighth] was more radical than the seventh but left unchanged the basic structure of the Classification and the general philosophy of classifying diseases, whenever possible, according to their etiology rather than a particular manifestation.” In this spirit, all diarrhoeal diseases were gathered in the chapter of infectious diseases, the infectious diseases are organized by their etiological agents, myelofibrosis is moved from the blood-forming organs diseases in the chapter of neoplasms. Vallin and Meslé (1988) however argue that against these etiological adjustments, several changes were made in the opposite sense and that the adoption of a clear logic giving preference to etiology was not evident. This statement finds support in the removal of allergic diseases (ICD7 items 240-245) from the chapter III and their placement

¹⁵ This step has a deeper meaning – it puts senility in line with other poorly defined states, reflecting the increasing refusal to accept age as cause of death.

along with the site of their manifestation in ICD8 (e.g. asthma and hay fever were moved to the chapter of respiratory diseases, urticaria to the chapter of diseases of skin).

The changes between chapters were however minor to the changes within them caused by frequent redefinitions of individual diseases (such as heart diseases, mental disorders, perinatal conditions, etc.). In the same publication, Vallin and Meslé finally conclude that even though the discontinuity caused by the introduction of the 8th ICD revision was important, the changes are traceable if sufficient level of detail of both classifications is available.

Ninth revision (1975)

The International Conference for the Ninth Revision of the International Classification of Diseases was convened by WHO for 1975. The preparations for the 9th revision were marked by the increasing demand to use the classification for hospital and medical care statistics on one side, and by the need of an ICD-based shortlist enabling for measuring the medical progress and disease control in the developing countries.

The substantial increase of classification detail was the natural consequence thereof. Compared to the 2875 codes of the ICD8, the ICD9 detail practically doubled: the total number of four-digit items increased to 5285. In addition, another classification level has been added, the optional 5th digit, which enables to record further diagnostic information or other precision (e.g. presence of remission in leukaemias, presence of obstruction in ulcers, type of diabetes, severity of mental disorders, treatment status for myocardial infarction, anatomic localization of some musculoskeletal diseases, the birth weight in premature deliveries, localization or extent of injuries).

Another innovation was the change of the preference in classifying the external causes of death. While since 1948, the circumstances of the accident were the given priority, with ICD9 the nature of injury (N-classification) is integral part of the list, while the E-classification became supplementary. The E-classification is however still considered primary for the mortality statistics.

The 9th revision also introduced a dual coding system to indicate both the etiology and manifestations of a disease, a concept of the double classification lately known as dagger-and-asterisk system. A code marked with an asterisk (*) represents the symptoms or manifestations of a disease, a second code, marked with a dagger (†) indicates the etiology of the disease, the two codes defining one diagnosis. Thus, for example, the death from a carditis caused by the Coxsackie virus should be coded as 074.2 as †, while its manifestation is coded as *Acute pericarditis in diseases classified elsewhere* (420.0*). The number of items allowing for dual coding (the dagger codes) is limited to approximately 150 in ICD9. The asterisk codes should not appear in mortality statistics, while they are never the underlying causes of death.

To meet the needs of developing countries, a new system of short and intermediate lists was introduced. The shortest is the basic tabulation list of 56 causes (BTL) which can be further subdivided into 210 items (plus remainders). It was recommended that these shortlists become part of the classification.

Tenth revision (1993)

Based on the experience with previous ICD revisions, WHO concluded that a 10 year revision interval is too short..¹⁶ ICD10 has therefore been designed as a „*stable and flexible classification, which should not require fundamental revision for many years to come*“.¹⁷ ICD10 introduced substantial change in the classification and is therefore considered another milestone in mortality statistics. Researchers do not hesitate to declare that ICD10 represents the “*largest change to mortality statistics in the last 50 years*”.¹⁸

The intention of the fundamental change was logically a double-edged weapon: classification has been adapted to current medical knowledge and its use across medical sciences increased, but it also introduced serious discontinuities in the cause-of-death time series.

The most visible feature of ICD10 is the introduction of an alphanumeric system of codes, which enabled a considerable increase of the classification detail. Thus, the number of categories increased from cca 5000 to approximately 8000 codes recognized as causes of death.¹⁹

The long-term structure of the main ICD chapters was rearranged: chapter VI of ICD9 has been split in three, the order of chapters III and IV has been interchanged, ICD9 chapters XII and XIII (diseases of skin and musculoskeletal systems) have been moved before diseases of genitourinary system (chapter X) and chapter XV is now placed before chapter XIV. The two supplementary classifications in ICD9 (the V- and the E-classification) have been integrated in ICD10; the total number of chapters thus increased from 17 to 21. Chapter titles have changed slightly as well (see Table 2).

Many ICD items changed and moved across the classification, in some cases between the ICD chapters. Once again, there was not a unique principle in rearranging the diseases. Thus, according to etiology, *Myelodysplastic syndromes* (formerly known as "preleukaemia") have been removed from the chapter of the diseases of the blood and blood forming organs (chapter IV in ICD9) and placed together with neoplasms of uncertain or unknown behaviour of chapter II in ICD10. Other exchanges tend to respect rather the anatomic localization of the disease. *Non-specific lymphadenitis*, placed in ICD9 chapter IV under Other diseases of blood and blood-forming organs (289) is a cardiovascular disease in ICD10 (I88). Several diseases were added to the chapter musculoskeletal diseases in ICD10: *adult osteomalacia* (M83), attributed previously to the *vitamin D deficiency* (268) of ICD9 chapter III, *gout* (M10) formerly part of endocrine, nutritional and metabolic diseases and immune disorders (274), and *polyarteritis nodosa* (M30.0), classified in ICD9 as a circulatory disease (446.0). *Transient cerebral ischemia*, a cerebrovascular disease in ICD9 (435), is now considered a disease of a nervous system (G45) and thus belongs to chapter VI. However, in spite of some etiological adjustments

¹⁶ The preparations take so much time that they have to start practically right after the release of the current revision, and the implementation of new revision is costly for the countries. Some countries consider not needing the increasingly complex classification and refused to implement ICD9 (Scandinavian countries in particular).

¹⁷ (WHO 2004), p. 110

¹⁸ (Rooney et al. 2002), p. 31

¹⁹ In total, ICD10 contains about 12.700 categories, but not all of them are valid as code for cause of death.

of the ICD10, the main deadly infections – pneumonia and influenza - remain classified within the respiratory diseases.

Apart from the relocation of the causes of death, some brand new categories were created in ICD10, namely *Malignant neoplasms of independent (primary) multiple sites* (C97) and *Mesothelioma* (C45). The SIDS (Sudden Infant Death Syndrome) was allocated a single 3-digit code (R95), while it was part of the Sudden death in ICD9 (798.0). The ICD9 code for “fracture, cause unspecified” (E887) does no more have its equivalent among fractures in ICD10; the deaths are now classified as due to exposure to unspecified factor (X59).

ICD10 kept the dagger-asterisk system, but the dual coding is no more limited to selected items. Any item can be dual coded if meaningful.

An important step from WHO was the release of an electronic document mapping the ICD9 to ICD10, which hypothetically allows for finding correspondences and establish continuity (WHO 1997) currently available at <http://libdoc.who.int/icd/hq/1996/>.

Table 2 List of ICD10 and ICD9 chapters

ICD10			ICD9		
Chapter	Codes	Title	Chapter	Codes	Title
I	A00-B99	Certain infectious and parasitic diseases	I	001-139	Infectious and parasitic diseases
II	C00-D48	Neoplasms	II	140-239	Neoplasms
III	D50-D89	Diseases of the blood and blood-forming organs and certain disorders involving the immune mechanism	III	240-279	Endocrine, nutritional and metabolic diseases and immune disorders
IV	E00-E90	Endocrine, nutritional and metabolic diseases	IV	280-289	Diseases of the blood and blood-forming organs
V	F00-F99	Mental and behavioural disorders	V	290-319	Mental disorders
VI	G00-G99	Diseases of the nervous system	VI	320-389	Diseases of the nervous system and sense organs
VII	H00-H59	Diseases of the eye and adnexa	VII	390-459	Diseases of the circulatory system
VIII	H60-H95	Diseases of the ear and mastoid process	VIII	460-519	Diseases of the respiratory system
IX	I00-I99	Diseases of the circulatory system	IX	520-579	Diseases of the digestive system
X	J00-J99	Diseases of the respiratory system	X	580-629	Diseases of the genitourinary system
XI	K00-K93	Diseases of the digestive system	XI	630-676	Complications of pregnancy, childbirth and the puerperium
XII	L00-L99	Diseases of the skin and subcutaneous tissue	XII	680-709	Diseases of the skin and subcutaneous tissue
XIII	M00-M99	Diseases of the musculoskeletal system and connective tissue	XIII	710-739	Diseases of the musculoskeletal system and connective tissue
XIV	N00-N99	Diseases of the genitourinary system	XIV	740-759	Congenital anomalies
XV	O00-O99	Pregnancy, childbirth and the puerperium	XV	760-779	Certain conditions originating in the perinatal period
XVI	P00-P96	Certain conditions originating in the perinatal period	XVI	780-799	Symptoms, signs and ill-defined conditions
XVII	Q00-Q99	Congenital malformations, deformations and chromosomal abnormalities	XVII	800-999	Injury and poisoning
XVIII	R00-R99	Symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified		V01-V85	Supplementary classification of factors influencing health status and contact with health services
XIX	S00-T98	Injury, poisoning and certain other consequences of external causes		E800-E999	Supplementary classification of external causes of injury and poisoning
XX	V01-Y89	External causes of morbidity and mortality			
XXI	Z00-Z99	Factors influencing health status and contact with health care			

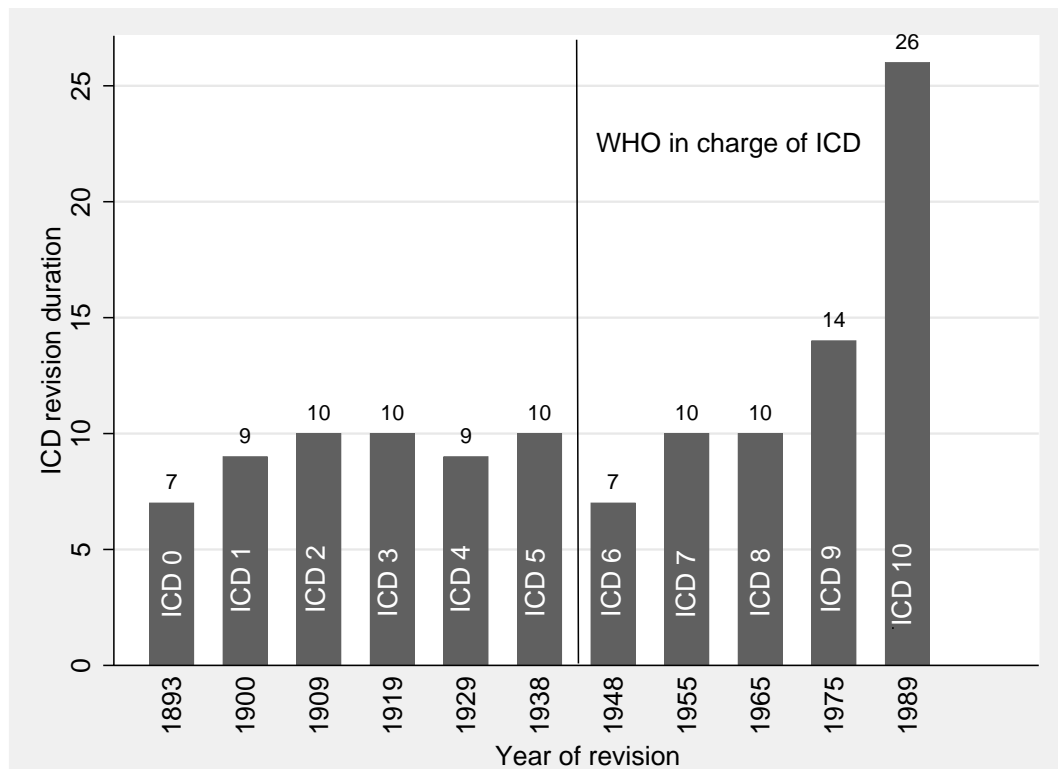
Eleventh revision (2015?)

Figure 1 represents the revision duration since the first international list in 1893. While until the 8th revision, the ten-year interval was, more or less, respected, ICD9 endured 14 years and the *expected* duration of ICD10 is of 26 years. The active work on the 11th revision has begun in 2007.

Like the previous revisions, the ICD11 will incorporate advances in medical progress: new diseases, new etiologic pathways, new treatments. The main medical advance to be incorporated in ICD is, however, the genomic medicine. In words of Dr. Chute, the ICD-11 Revision Steering Group Chair: „*The genomic transformation of medicine far exceeds the introduction of antibiotics and aseptic surgery. The binding of genomic biology and clinical medicine will accelerate.*” (Chute 2008)

Unlike the previous revisions, the ICD11 will provide exact definition of basic classification entities (disease, disorder, injury, syndrome, sign, and symptom). The classification structure will then be based on definitional characteristics of diseases, consisting of names, synonyms and inclusions on one hand, and of additional criteria on the other. These criteria include: pathophysiology, anatomical site, manifestation attributes, etiology (causal agents, mechanism, genomic characteristics), temporal relations (chronicity/acuity, periodicity, and severity/extent (WHOFIC 2007). It seems that with ICD11, the WHO will, eventually, employ multiple axes of classification.

Figure 1 Intervals between ICD revisions



The ICD11 thus increasingly aims to be a multi-purpose classification, suiting the needs of 1) research (epidemiology), 2) clinical practice (decision support, treatment response, phenotypes) and 3) public health (risk factors, e-health systems). To allow for such interdisciplinary, the classification will be connected to the existing medical terminologies; the most discussed for ICD11 is the SNOMED²⁰ system. Logically, with such concept, another rise in the classification detail is unavoidable. Therefore, the classification will probably be hierarchically scaled (via collapsing and expanding) to give several lists meaningful for the study of mortality, morbidity or clinical practice.²¹

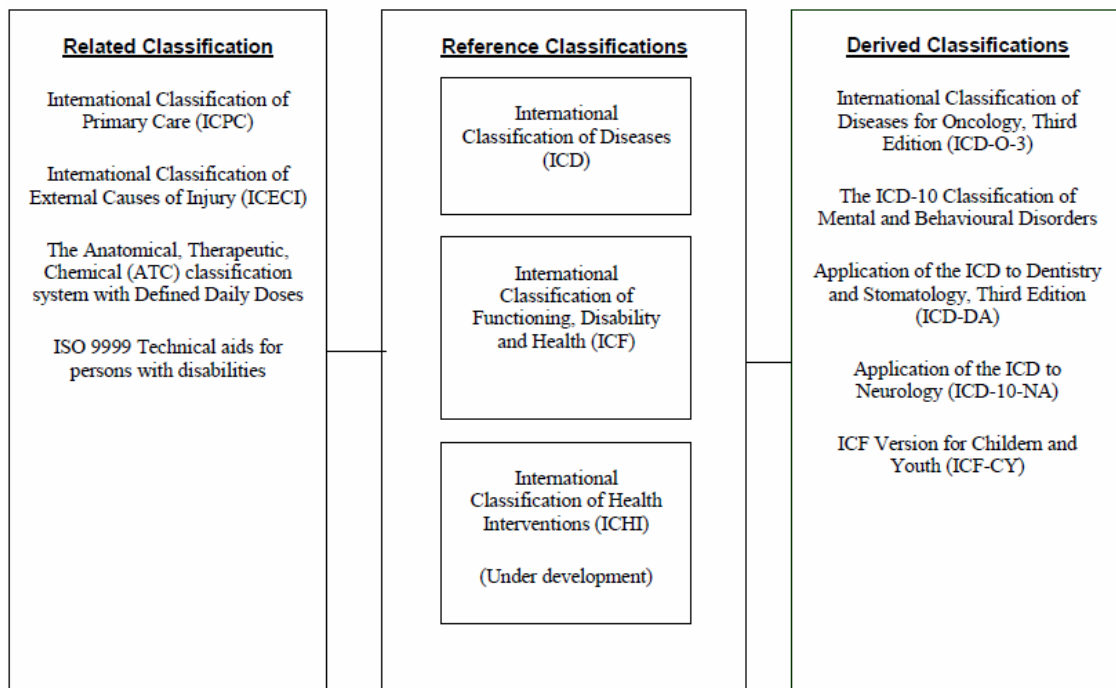
Another aim of the 11th revision is to increase the intercompatibility of various sources of health information. In 2001, ICD became one of the reference classifications in the World

²⁰ Systematized Nomenclature of Medicine

²¹ So far, several countries developed their own modification of ICD for clinical purposes. The best known is the US ICD-CM. These clinical modifications serve as one of the bases for the ICD11 update process.

Health Organization's Family of International Classifications (WHO-FIC). The reference classifications cover the main parameters of health and the health system, such as death, disease, functioning, disability, health and health interventions and serve as a basis for deriving other specialized classifications (Figure 2). In order to fully profit of the information complexity provided by the WHO-FIC, the compatibility within the increasing number of the member classifications is necessary.

Figure 2 The WHO Family of International Classifications



The update process itself was updated for ICD11 too. The main changes include: 1) the update will take place in the web-based environment, using a wiki-like tool; 2) the work is divided into topic-related groups (mental health, external causes, oncology, internal diseases, rare diseases); 3) a beta version of ICD11 will be released (and field tested) before its official launch.

2.2 Multiple causes of death and coding rules

Along with the development of disease classification, another important issue became apparent: how to transform all the information on the death certificate into a simple, reliable and internationally comparable source of statistical information. Moreover, the advances of diagnostics and certification, hand in hand with the increasing number of recognized medical entities, have led – already since the second half of the 19th century – to conclusions that death is much more a result of multiple degenerative processes than an outcome of a single disease

(Srb and Haas 1956)²². Naturally, in more and more cases multiple causes of death appeared on death certificates, reflecting either the physicians' incertitude to decide about a single major cause, or a good will to report all the existing information about the train of events leading to death. The certifying practitioners have always been those who decide about a single cause of death. Still, for several reasons, their choices are sometimes mistaken or not taken at all, and have to be corrected or completed. To do so in a uniform way, a system coding rules was developed.

The coding rules have been evolving along with the revisions of the ICD. These rules have been growing more and more precise and complex. The timing of the change in the coding rules might considerably differ between individual countries (Meslé 1995) and, consequently, affect the international comparability of the cause-of-death data. Understanding the mechanisms leading from certifying multiple diagnoses to a single tabulated cause, which is the basis for our work, is therefore essential.

Bertillon was well aware of the need to deal with multiple (or joint) causes reported on death certificates, and along with the first revision of ICD (1900) he proposed a set of rules to facilitate the statistical processing of death certificates where more than one disease is reported without distinction of the main cause of death. The issues of multiple causes of death were then re-discussed at every upcoming revision conference, but an internationally approved solution was only accepted at the 6th decennial conference in 1948.

Meanwhile, the countries developed and used their own systems. In 1914 the United States elaborated a complex selection tool named "Manual of joint causes of death". Technically the manual was based on mutual cross tabulation of every item of the detailed ICD list, while only those which were to be given preference, if both conditions were cited on the death certificate, were printed. The creation of such table had to be preceded by ideological consensus about the importance of specific causes of death for statistical tabulation. Thus, for example, it was agreed that the initiating cause of death was to be given preference against the condition causing the death directly (immediate condition), epidemic or puerperal diseases, as well as accidents, were to be preferred over other causes (e.g. influenza over heart disease) and so on.

Manual of joint causes of death was revised with each consecutive ICD revision, and was used in some countries, but never really became an internationally approved standard nor an integral part of the classification. In 1945, as was said already, the United States appointed a Committee on Joint Causes of Death, whose work finally resulted in a new revision and a radical change of the classification system (see section Sixth revision of this chapter).

In the name of improvement of international comparability of cause-of-death data, death certificate and coding rules became an integral part of the classification. As compared to the changes in the classification, both the death certificate and the coding rules remained relatively stable over time since 1948.

²² In the same publication, the authors give the proportions of joint causes of death on the death certificates around 1947: France 3%, Italy 20-30 %, Canada 44 %, Switzerland 60%, USA 55 % (based on the UN Demographic Yearbook 1951).

2.2.1 International form of death certificate

Figure 3 represents the international death certificate, as recommended by the tenth revision of the ICD. The first part of the certificate (I) describes the train of conditions and events leading directly to death, with the underlying condition on the last line. The second part (II) of the certificate provides additional information on diseases diagnosed simultaneously at the moment of death, which are not believed to contribute directly to the fatal outcome. The part I of the death certificate is sub-divided into the information about the immediate (direct) (a), the intervening (b, c) and the underlying (main, initial) (d) cause of death.²³ The certificate should also contain information about the time elapsed between the onset of the disease and the death, which helps the certifying practitioner to establish the correct sequence of conditions and can also help the coder to choose the proper underlying cause.²⁴

Figure 3 International form of medical certificate of death, as recommended by WHO in 1990

Cause of death		Approximate interval between onset and death
Part I		
Disease or condition directly leading to death* a)	Due to (as consequence of)	
Antecedent causes		
Morbid conditions, if any, giving rise to the above b)	Due to (as consequence of)	
cause, stating the c)	Due to (as consequence of)	
underlying condition last d)		
Part II		
Other significant conditions contributing to death, but not related to the disease or condition causing it		
*This does not mean the mode of dying, e.g. heart failure, respiratory failure. It means the disease, injury or complication that caused death.		

Since 1967 the WHO recommends to report "all those diseases, morbid conditions or injuries which either resulted in or contributed to death and the circumstances of the accident or violence which produced any such injuries" to assure that only the relevant conditions are reported on the death certificate.

2.2.2 Selection of underlying cause of death

Among all the diseases reported on the death certificate, solely the **underlying cause of death** has, up to present, been coded in most countries, including West Germany and Czech Republic. The underlying cause of death is defined by WHO as "*the disease or injury that initiated the train of events leading directly to death, or the circumstances of the accident or violence that produced the fatal injury*" and was selected by the Sixth Decennial International Revision Conference in 1948 as the primary cause of death for tabulation. With increasing interest in the mechanisms of dying, and thanks to the spreading use of electronic data

²³ The current version of the international death certificate (adopted in 1990 on 43th World Health Assembly) contains four lines to certify the chain of pathologies in the section I, but most of the German Länder, as well as the whole Czech Republic, use only three lines in section I of the death certificate.

²⁴ If the information about the duration of the disease and the death is not known, it should be estimated by the certifying practitioner.

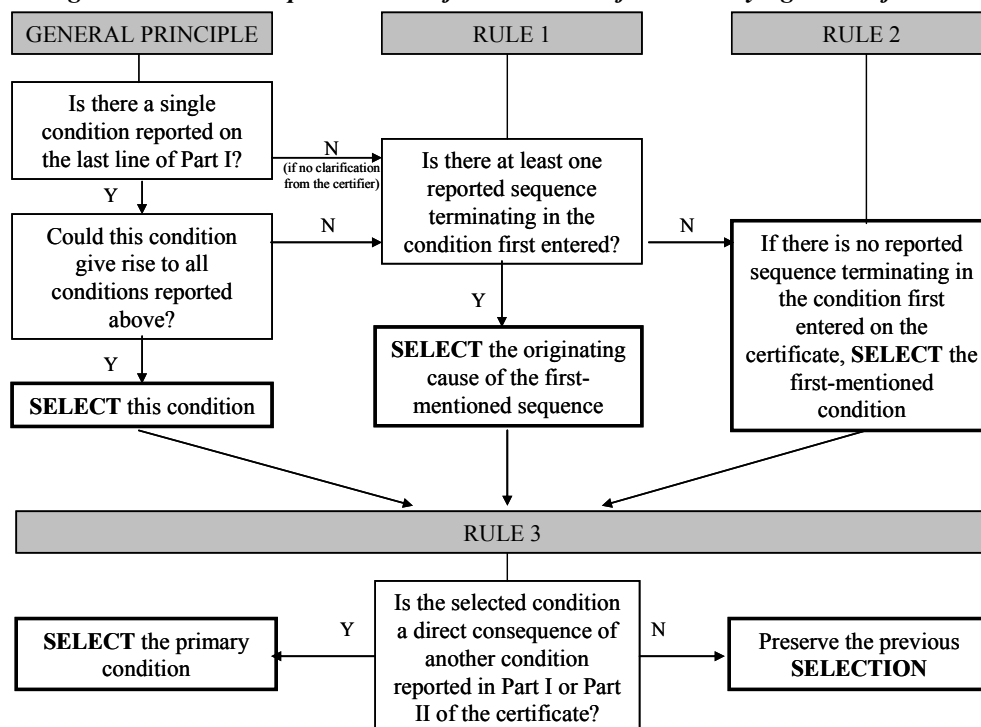
processing, it is however very likely that in the near future, statistical offices will process all the significant contributing conditions present on the death certificate (typically hypertension, renal failure, obesity, asthma or diabetes).

As the structure of the international death certificate suggests, the **underlying cause of death is primarily meant to be selected by the certifying practitioner**. A properly completed cause-of-death section of the death certificate thus provides an etiologic explanation of the order, type, and association of events resulting in death. However, the death certificates are often filled incompletely or incorrectly, which forwards the task of the determination of the underlying cause of death towards the coders.

Figure 4 illustrates how the selection of the underlying cause of death works in practice. There is one General Principle and there are three subsidiary Selection Rules. The third selection rule works as a filter for the previous selections. Finally, there are several Modification Rules (A-F). When more than one cause is reported on the death certificate, the task is to determine the underlying cause by applying the General Principle or Rules 1-3. Modification Rules then deal with special epidemiological circumstances where other conditions are more relevant for tabulation than are the condition selected by General Principle or Selection Rules.

Rule 3 is subject to numerous precisions and therefore is a possible source of important statistical discontinuities. Spectacular is the example of Great Britain. Until 1983, Rule 3 was not applied strictly, leading to an artificial increase in mortality from immediate causes of death reported on the first part of the death certificate, and the major underlying disease reported in the second part was ignored. In 1984, new coding instructions applied and mortality from pneumonia and influenza dropped immediately to less than half of its value in 1983 (Meslé 1995).

Figure 4 Schematic representation of the selection of the underlying cause of death



The following lines are a subset of examples of underlying cause selection, as given by the WHO ICD manual.

The General Principle

The exact wording of the General Principle is the following: *“When more than one condition is entered on the certificate, the condition entered alone on the lowest used line of Part I should be selected only if it could have given rise to all the conditions entered above it.”*

Therefore, in the two given examples the underlying cause of death (in bold) will be selected directly from the last line of the sequence reported on the death certificate.

- Example 1: I. a) Uremia
 b) Urine retention
 c) Prostate hypertrophy

II.

The General Principle applies also if the order of the reported sequence is not correct, but the underlying cause on the lowest line could have given rise to all the conditions listed above (see example 2).

- Example 2: I. a) Generalized metastasis
 b) Bronchopneumonia
 c) Cancer of bronchus

II.

In some cases the general principle is not applicable: either the described chain is not coherent (the diseases cannot be a consequence of a disease on the precedent line) or more pathologies are given in one line, suggesting of more possible etiological chains. It is recommended by WHO (and practiced in Germany, but not possible in Czech Republic) that the certifier is asked by the coders for clarification. If clarification cannot be obtained, three selection rules apply.

Selection Rule 1

If the General Principle does not apply and there is a reported sequence terminating in the condition first entered on the certificate, select the originating cause of this sequence. If there is more than one sequence terminating in the condition mentioned first, select the originating cause of the first-mentioned sequence.

According to Rule 1, in example 3 the ischemic heart disease will be coded as underlying cause, while influenza it very unlikely to cause the ischemic heart disease and subsequently the myocardial infarction.

- Example 3: I. a) Acute myocardial infarction
 b) Ischemic heart disease
 c) Influenza

II.

In example 4 two sequences were reported: cerebral infarction giving rise to bronchopneumonia and hypertensive heart disease giving rise to bronchopneumonia. Cerebral infarction will be selected as the underlying cause of the first-mentioned sequence.

- Example 4: I. a) Bronchopneumonia
 b) **Cerebral infarction** and hypertensive heart disease

II.

Selection Rule 2

If there is no reported sequence terminating in the condition first entered on the certificate, select this first-mentioned condition.

Therefore, in example 5 pernicious anaemia will be selected according to Rule 2, as neither atherosclerosis nor gangrene causes pernicious anaemia.

- Example 5: I. a) **Pernicious anaemia** and gangrene of foot
 b) Atherosclerosis

II.

Selection Rule 3

If the condition selected by the General Principle or by Rule 1 or Rule 2 is obviously a direct consequence of another reported condition, whether in Part I or Part II, select this primary condition.

A list of assumed direct consequences of the selected conditions follows.²⁵ Rule 3 can be regarded as a filter applied to the results of General Principle and Rules 1 and 2 and has an important impact on the result of the coding, while it concerns common conditions such as pneumonia and bronchopneumonia, embolism, malignant neoplasms and HIV. The rule 3 is also a subject of numerous changes and precisions and is therefore a possible source of important statistical discontinuities. Such example might be a recent change in the coding of pneumonia and bronchopneumonia as possible complications of any disease under ICD10. This change in the coding instructions resulted in a decrease of pneumonia as underlying cause of death with the implementation of ICD 10 in Austria (Leitner 2004).

In example 6, bronchopneumonia would have been selected by the General Principle as underlying cause of death. Applying Rule 3, chronic lymphatic leukemia can be selected even though it is reported as a second condition in Part II of the certificate.

- Example 6: I. a) Bronchopneumonia
II Secondary anaemia and chronic lymphatic leukaemia

²⁵ The detailed list of the circumstances where particular conditions can be assumed to be a direct consequence of another condition reported on the death certificate (Rule 3) can be found in the respective ICD manuals.

Chapter II.

Compilation of mortality statistics

The idea of a scientific classification of diseases dates from the mid-18th century, the first internationally approved concept appeared one century later, and the first successful classification – Bertillon's list – came only by the end of the 19th century. Meanwhile, the data on causes of death began to be collected and recognized as valuable source of information for modern – increasingly statistics-based - governments. In absence of international classification, the states developed their own ways to collect and classify cause-of-death data. This section describes the early origins of the cause-of-death collection in the three countries and their diverse ways to adoption of ICD.

3.1 The origins of cause-of-death data collection

3.1.1 Germany

Prior to the first unification of Germany in 1871, the registration of causes of death was non-systematic and primarily aimed at monitoring and preventing the Middle-Ages infectious epidemics. The view of the role of cause-of-death statistics began to change with the works of Johann Süssmilch (the mid-18th century), which stressed the advantages of cause-specific mortality data for the evaluation of epidemic situation and their use as a proxy measure of living conditions. Thus, according to (Kintner 1999), one of the first interests of the public health officials in Germany were the evaluation of Jenner's smallpox vaccination (as of 1796), suicides, and the effect of campaign against other particular diseases.

By the time of the first German unification, each of the 26 Länder had its own statistical system at a different degree of development²⁶, creating a great regional variation in cause-of-

²⁶ A common feature of these systems however was the use of the counting cards (Zählenkarten), which transmitted the information from death certificate into a standardized format suitable for statistical tabulation.

death systems.²⁷ After the foundation of the German empire, requests for a uniform national statistical system arose. A survey on regional vital registration systems, conducted at this occasion, revealed large disparities across the statistical systems in German Länder. While nearly all states recorded time and place of death, sex, age and occupational status, the cause of death information had been collected in only sixteen out of the total of twenty six states. Moreover, six of these sixteen countries collected only minimal information – that of the accidental or violent death (Kintner 1999).

In 1874, a commission was created to prepare the unification of the German statistical system (*Kommission zur Vorbereitung einer Reichsmedizinalstatistik*). Two years later the vital registration passed from religious authorities to civil registrars and the Imperial Health Office (*Reichsgesundheitsamt*) was founded (1876). The Imperial Health Office then compiled single cause-of-death statistics between 1877 and 1924, the first published statistics however concerned only cities with >15000 inhabitants. Nevertheless, the quality of cause-of-death data remained unevenly regionally distributed: the Länder differed in the date of introduction of mandatory post-mortem examination, in the type of person allowed to certify death²⁸ as well as in the rules for selecting the single cause. In rural Prussia, the last (most recent) disease was to be selected, while Hesse adopted the concept of underlying cause of death (the diseases which caused the chain of pathologies) in 1868.

In 1891 the Imperial Health Office released a single form for collecting cause of death data from Länder, requesting number of inhabitants, live births, stillbirths and death by four age groups and 18 causes of death. Majority of Länder (15 out of 26) however joined this system only in 1904. The system was revised in 1905 and in 1906 uniform statistics became available for all the German territory, including rural areas. In 1925 the task of compilation of cause-of-death statistics was transferred to the Imperial Statistical Bureau (*Statistisches Reichsamt*).

The numerous regional statistical systems in Germany also developed numerous classifications. Kintner claims there had been at least nineteen different classifications in use on the German territory until 1932, when ICD was adopted.²⁹ The Imperial Health Office was in charge of centralized classifications of causes of death since 1877. Its first short classification was aimed mainly at infectious diseases and violent deaths.³⁰

1. *Smallpox*
2. *Measles*
3. *Scarlet fever*
4. *Diphtheria*
5. *Croup*
6. *Typhus abdominalis*
7. *Spotted fever*

²⁷ By the time of the unification, there have been seventeen separate statistical offices (Kintner 1999).

²⁸ Some parts of Germany (especially Prussia) have, for example, long hesitated to introduce a mandatory post-mortem examination and it has been estimated that even in the 1920 up to 8.5% of deaths of German population (living in cities of more than 15000 inhabitants) were not certified by a physician.

²⁹ It is interesting to note that in 1868, Hesse, as possibly the only region in the world, adopted the “first” international classification of Farr/d’Espine (in fact, its first revision adopted by the 1857 ISC meeting in Vienna).

³⁰ This is author’s translation to English from Kintner (1999).

8. *Stiff neck (meningitis)*
9. *Cholera*
10. *Puerperal fever*
11. *Consumption (of lung)*
12. *Acute diseases of respiratory organs*
13. *Acute intestinal catarrh*
14. *Violent causes of death*

This classification scheme was revised in 1892, when the number of titles increased to eighteen, but the acceptance remained low (only nine Länder adopted it, while others continued using their own classifications). The regional diversity was of such magnitude, that according to Edge: “...no comparison of mortality data between the various States is possible before 1905...” (Edge 1928).

Table 3 Classifications on the German territory (since the foundation of the Imperial Health Office)

Year	Classification	Note
1877	IHO*	14 items, each state statistician used its own version of the classification (Kintner 1999)
1892	IHO	„Federal“ nomenclature, 4 age groups and 18 causes of death, but adopted in 1892 only by nine Länder and Alsace-Lorraine, 15 more Länder joined in 1904
1905	IHO	335 medical terms grouped into 23 titles. As of 1910 an extended list of 50 titles used in cities
1932	ICD4	German modification of ICD
1941	ICD5	1941-1948: a short tabulation list 1949-1951: detailed international list
1952	ICD6	FRG full detail, GDR 3-digit, in GDR used also for morbidity coding
1958	ICD7	FRG full detail, GDR 3-digit, in GDR used also for morbidity coding
1968	ICD8	FRG full detail, GDR 3-digit, in GDR used also for morbidity coding
1979	ICD9	FRG full detail, GDR 3-digit, in GDR used also for morbidity coding. In FRG used 3-digit for morbidity since 1986, 4-digit since 1994
1997	ICD10	

* Imperial Health Office

In 1905, the new revision was adopted, based on 335 medical terms grouped into twenty-three titles.³¹ This classification, although not compatible with the international classification, was in use for the upcoming 27 years in the whole Germany. The ICD was adopted only in 1932, and its adoption is credited to the efforts (the above mentioned) Dr. Roesle, the first German delegate to the Conference for Introduction of the Third Revision and a member of the Commission to Prepare the Fourth Revision. After 1932, the classification was continuously synchronized with WHO. See Table 3 for a summary of the classifications on the German territory since the foundation of the Imperial Health Office, which began to unify diverse regional statistical systems.

³¹ In 1910 the German cities adopted an extended version of 50 titles.

3.1.2 Czech Republic

In the current Czech territory the causes of death at have been collected as early as of 1785, when nation-wide systematic vital events civil registration was institutionalized by Joseph's II imperial patent of 1784. Nevertheless, according to Srb and Haas (1956), these earliest data were never published and are probably lost. The first cause-of-death scheme, given by the imperial patent, comprised a basic distinction between violent (suicide, accident or homicide) and natural death from usual, local or epidemic disease. Similar to Germany, the collection of early cause-of-death information was primarily motivated by surveillance of epidemics.

Following the court decree of 1828, yearly vital registry reports were introduced and data were published in the bulletin of *Wiener Zeitung*. The cause-of-death classification was updated in 1851 by including cholera, smallpox and late effects of difficult labour. The external causes were enriched by bite and execution, data were collected by sex.

In 1871, a new classification scheme was introduced by the Ministry of Health, comprising 17 categories:

1. *Congenital weakness in children under 1 year*
2. *Smallpox*
3. *Measles*
4. *Scarlet fever*
5. *Typhus*
6. *Dysentery*
7. *Cholera*
8. *Whooping cough*
9. *Inflammation of respiratory tract*
10. *Tuberculosis of lung*
11. *Intestinal catarrh*
12. *Sudden death*
13. *Neoplasms*
14. *Rabies*
15. *Senility*
16. *Other diseases*
17. *Violent death*

This basic scheme went unchanged until 1895, although in the course of time new diseases and subdivisions were added according to the current statistical needs (Srb and Haas 1956). In 1895, the vital registration system changed completely. The main change was that the civil registry officers no more summarized vital events, but were asked to send individual reports on special forms. These reports were sent on quarterly basis to regional offices, where medical doctors checked the diagnoses, extracted public health information, and evaluated the population movement. The reports were then transferred to vice regencies and then to the central statistical commission for nationwide processing. The new 1895 classification contained 25 causes of death, its structure still reflected the contemporary epidemiologic profile, but it

already contained degenerative diseases other than senility – cancer and cardiovascular diseases and stroke:

1. *Congenital weakness due to premature birth or abortion*
2. *Tuberculosis (all forms)*
3. *Pneumonia*
4. *Diphtheria*
5. *Whooping cough*
6. *Smallpox*
7. *Scarlet fever*
8. *Measles*
9. *Typhus*
10. *Typhoid fever*
11. *Dysentery*
12. *Asian cholera*
13. *Infant diarrhoea*
14. *Diarrhoea at higher ages (enteritis acuta, cholera nostras)*
15. *Puerperal fever*
16. *Wound infections (erysipelas, phlegmona, lymphangiotitis, pyemia, septicaemia, tetanus)*
17. *Other infectious diseases (chickenpox, influenza, recurrent fever, meningitis, malaria, syphilis)*
18. *Animal-borne diseases (rabies, anthrax, trichinella, glanders)*
19. *Cerebral stroke – apoplexia cerebri*
20. *Organic heart lesions and cardiovascular diseases*
21. *Malignant neoplasms - carcinoma, sarcoma*
22. *Other natural causes of death*
23. *Accidents*
24. *Suicide*
25. *Homicide and manslaughter*

This scheme was in use until the end of the Austrian empire. Right after the WWI, the Czechoslovak Republic adopted the third revision of ICD and since then has always ranked among the first countries to keep abreast with the decennial ICD updates (see Table 4).

In spite of relatively frequent updates of the Austrian classifications (before 1918), Srb and Haas (1956) consider these statistics as with very good backward compatibility. Comparability after 1918 however has one important obstacle: since ever, and officially since 1895, the cause of death to be reported was the immediate disease (not the underlying cause of death). This was changed only in 1954, but even after there has certainly been inertia in the habits of Czech medical doctors and vital registry officers.

Table 4 *Classifications on the territory of Czech Republic (since the beginning of vital registration)*

Year	Classification	Note
1785	Joseph II patent	Data not published
1828	Court decree	
1851	Dept. of Home Affairs	
1871	Dept. of Home Affairs	
1895	Dept. of Home Affairs	
1919	ICD3	
1931	ICD4	
1941	ICD5	
1949	ICD6	
1958	ICD7	
1968	ICD8	
1979	ICD9	
1994	ICD10	

3.1.3 France

The first known cause-of-death information in France dates from 1767: a 5-year table of deaths in Nîmes, inspired by the classification of Boissier de Lacroix. This attempt remained solitary; the next event in French history of cause-of-death registration was the survey conducted in 1776 among physicians with intention to identify the contemporary epidemics across France. The onset of systematic collection (then limited to the region of Paris) dates back to 1802. Based on these data, the first nomenclature of 190 causes of death on the French territory appears in 1808. The rest of France takes hundred years to catch up with Paris to establish a modern cause-of-death registration.³²

As of 1885 the collection of causes of death was institutionalized nationwide in cities with more than 10,000 inhabitants. First annual publication comprised only major infections, the next year the classification scheme was extended to 27 items.³³

France was the first of the three countries of our interest to adopt ICD. It did so in 1901 by implementing the revised scheme of 35 causes of death (ICD1), but only for cities of more than 10,000 inhabitants. Five years later the statistics cover all the territory whatever the size of the commune, the age group detail however continues to be given only for cities with more than 30,000 inhabitants.

A complete statistics of deaths by cause became available in France only in 1925. Since 1925 the cause of death was systematically recorded on the statistical bulletin at the vital registry office based on the declaration of the cause of death by the attending physician or, if not possible, by the family or witnesses of death. These records were then sent for the processing at the central statistical office. The year 1925 is therefore designated as the beginning of the modern cause-of-death statistics in France (Vallin and Meslé 1988).

³² Several cities however established their proper registration systems, but according to Vallin and Meslé (1988), only around the mid-18th century these systems became comparable to that of Paris.

³³ This classification later on served as basis for the future ICD.

The system was updated in 1937 by implementing mandatory medical certification of cause of death. Moreover, the medical information was made confidential: the death certificate was to be first opened at the Regional Health Office, where the inspecting physician copied the diagnosis to the statistical bulletin to be sent to the central statistical office. Since 1945 the cause-of-death statistics are under the conduct of the National Institute of Statistics and Economic Studies (INSEE - Institut national de la statistique et des études économiques).

Table 5 Classifications of cause of death in France

Year	Classification	Note
1885	Ministry of business and industry / Public health office	Comprises only 7 infectious diseases
1886	Ministry of business and industry / Public health office	27 items
1901	ICD1	Since 1906 the statistic available for all the territory
1910	ICD2	
1920?	ICD3	
1930	ICD4	
1944	ICD5	
1950	ICD6	
1958	ICD7	
1968	ICD8	
1979	ICD9	
2000	ICD10	

3.2 Current cause-of-death statistics

A thorough look at the way the cause-of death data are compiled is another foresightful step when comparing these data on the international level. The contemporary cause-of-death statistics in developed countries are usually based on a compromise between the WHO recommendations and both the continuity of historical habits and the national specific needs. Most countries use a form inspired by WHO international death certificate as primary entry for diagnosis, allow only medical doctors to certify the (cause of) death, use the ICD system for selecting and coding the underlying cause of death, tabulating the underlying cause of death etc. Behind these main features, differences persist in the ways of processing the initial information on death certificate into the tabulated cause-specific death counts, which serve as basis for demographic analyses. This section describes three different systems as they exist (or have recently existed) in West Germany, Czech Republic and France.

3.2.1 West Germany

The statistical information about causes of death in West Germany is compiled from two sources. Most of the information for mortality analysis is transmitted from the death certificate filled out by medical doctors, while the complementary socio-demographic data come from vital record registries. The transmission of the two sources of information is slightly different, among

other reasons due to the high confidentiality of the medical data. The regulations concerning reporting and transmitting causes of death also differ between the German Länder.

The following scheme shows the current practice of cause-of-death certification and compilation in Germany, which kept many of these historical aspects. The collection of mortality data is a task of **regional** health and statistical offices, while the Federal Statistical Office (Statistisches Bundesamt) summarizes these regional data into national statistics.

The diversiform history of Germany with strong autonomy of individual Länder also left a legacy in the form of regional disparities of some aspects of data collection, such as the form of death certificate or different ways of transmission in case of non-natural death.³⁴

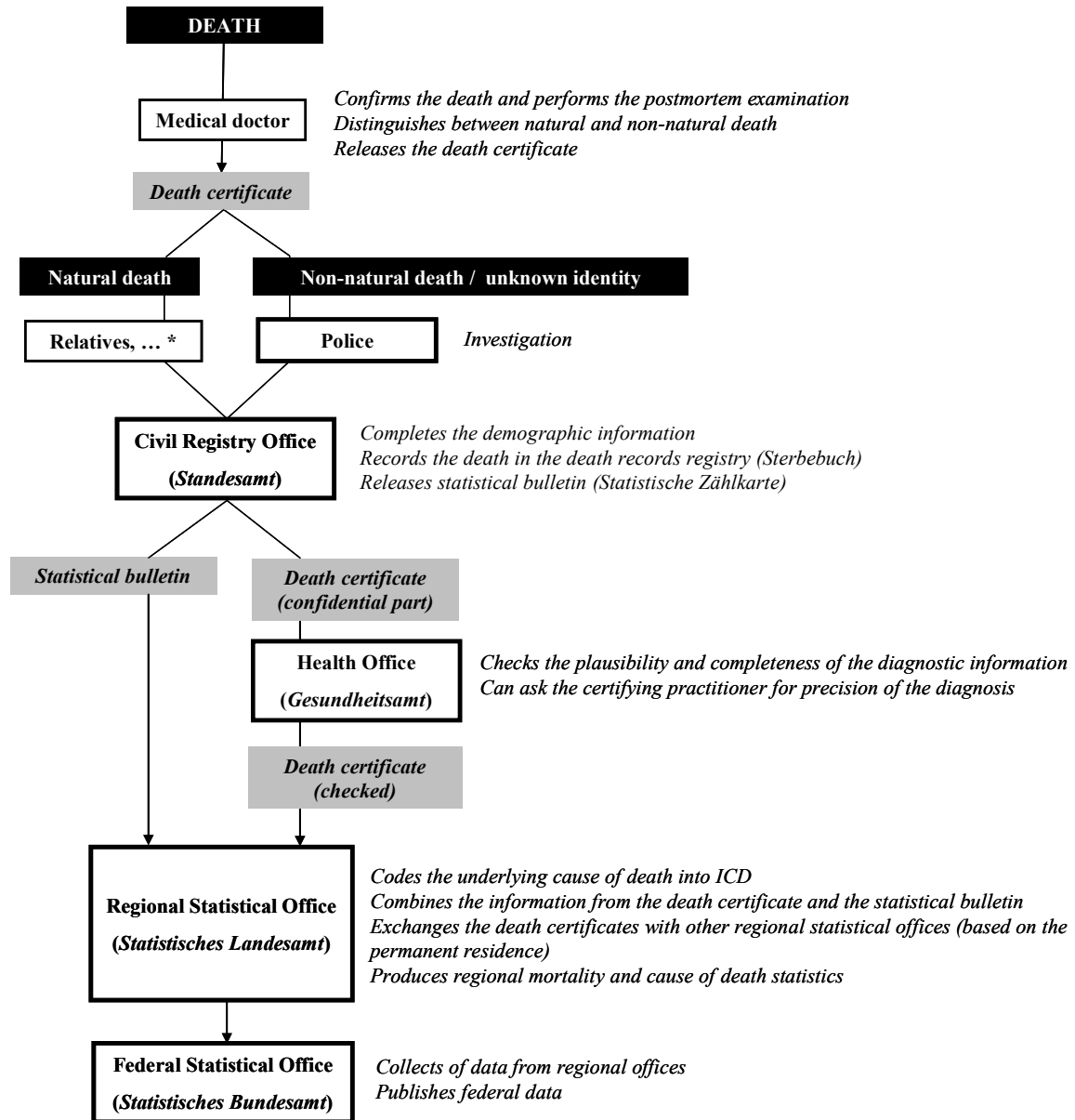
When a death occurs, the corpse is examined by a medical doctor, who confirms the death and reports:

- the time and place of death;
- the manner of death (natural, non-natural, unknown);
- the cause of death.

Based on the results of the - mandatory - postmortem examination, the medical doctor releases the death certificate (called differently in various German Länder, either *Todesbescheinigung*, *Leichenschauschein*, or *Totenschein*) (see Figure 6 for example of Bavaria). The death certificate has two parts, a non-confidential section and a confidential one. The non-confidential section contains the time and place of death, the manner of death, and usually a note on the presence or absence of infectious disease at the moment of death. The confidential part contains information on the cause of death and serves as the basic document for cause-of-death statistics.

The collected cause-of-death information across the Länder is virtually the same, consisting of the causal chain of pathologies as recommended by WHO and an additional classification for non-natural deaths. In Bavaria, the certifier is provided with an additional sheet to report his findings of evidence of violent death and he can also give a further description of the contributing conditions. Providing such complementary data could potentially increase the resulting data quality, because with more information it later can be easier to select the correct underlying cause of death (Jahn et al. 1995). As for natural deaths, also the transmission of death certificate is nearly the same in all the Länder: the death certificate always passes first through the Civil Registry Office (Standesamt).

³⁴ Legislation regarding postmortem examination, filling in death certificate, the burial and transmission of cause-of-death and related information actually rests with the regional stats, i.e. each Bundesland. Requirements of postmortem examination and of the content and transmission of death certificate are usually subject to the burial law (*Bestattungsgesetz*).

Figure 5 Schematic representation of the cause-of-death data collection in Germany (case of Bavaria)

* If the death occurred in an institution, the statistical bulletin is filled in by the institution and then sent directly to the regional statistical office (Bubenheim 2000).

Figure 6 Death certificate (Todesbescheinigung) in Bavaria: confidential section, part 1

Blatt 1: Gesundheitsamt		Todesbescheinigung – Vertraulicher Teil 1 –		(gelb)
Personalangaben				
Name ggf. Geburtsname, Vorname		Wird vom Standesamt ausgefüllt	Standesamt	
Straße, Hausnummer			Sterbefall beurkundet, Sterbeprot.-Nr.	
PLZ, Wohnort, Landkreis			Eintragung vorgemerkt, Vormerkliste-Nr.	
Geburtsdatum Tag Monat Jahr		Geburtsort		
Sterbezeitpunkt, ggf. Datum der Leichenauffindung Tag Monat Jahr Uhrzeit: Stunden Minuten		Geschlecht: <input type="checkbox"/> männlich <input type="checkbox"/> weiblich		
Zuletzt behandelnde(r) Ärztin/ Arzt				
Name und Telefonnummer der/des behandelnden Ärztin/Ärztes oder Krankenhaus, Straße, Hausnummer, PLZ, Ort				
Sichere Zeichen des Todes				
<input type="checkbox"/> Totenstarre <input type="checkbox"/> Totenflecke <input type="checkbox"/> Fäulnis <input type="checkbox"/> Verletzungen, die nicht mit dem Leben vereinbar sind <input type="checkbox"/> Hirntod Reanimationsbehandlung: <input type="checkbox"/> ja <input type="checkbox"/> nein Reanimation passager erfolgreich (Wiedereinsetzen der Herzaktivität): <input type="checkbox"/> ja <input type="checkbox"/> nein				
Todesart				
<input type="checkbox"/> natürlicher Tod <input type="checkbox"/> Todesart ungeklärt <input type="checkbox"/> Anhaltspunkte für einen nicht natürlichen Tod				
Anhaltspunkte für einen nicht natürlichen Tod				
<div style="text-align: right;"><input type="checkbox"/> weitere Angaben siehe vertraulicher Teil 2</div>				
Todesursache/ Klinischer Befund				
Bitte nur eine Todesursache pro Feld, nicht Endzustände wie Atemstillstand, Herz-Kreislaufversagen, Kachexie usw. eintragen				
I. Unmittelbar zum Tode führende Krankheit		a) unmittelbare Todesursache		Zeiddauer zwischen Beginn der Krankheit und Tod
Vorangegangene Ursachen Krankheiten, die die unmittelbare Todesursache unter a) herbeigeführt haben, mit der ursprünglichen Ursache (Grundleiden) an letzter Stelle		b) als Folge von		ICD-Code
II. Andere wesentliche Krankheiten		c) als Folge von (Grundleiden)		
Obduktion angestrebt? <input type="checkbox"/> ja <input type="checkbox"/> nein				
Angaben zur Todesursache und zu Begleiterkrankungen (Epikrise)				
<div style="text-align: right;"><input type="checkbox"/> weitere Angaben siehe vertraulicher Teil 2</div>				
Weitere Angaben zur Klassifikation der Todesursache				
Z.B. bei Unfall, Vergiftung, Gewalteinwirkung, Selbsttötung sowie bei Komplikationen medizinischer Behandlung		Äußere Ursache der Schädigung (Angaben über den Hergang)		
Unfallkategorie (bitte nur eine Untergruppe ankreuzen)		Bei Vergiftung: Angabe des Mittels		
		ICD-Code		
		<input type="checkbox"/> Schulunfall (ohne Wegeunfall) <input type="checkbox"/> Arbeits- oder Dienstunfall (ohne Wegeunfall) <input type="checkbox"/> Verkehrsunfall <input type="checkbox"/> häuslicher Unfall <input type="checkbox"/> Sport- oder Spielunfall (nicht in Haus oder Schule) <input type="checkbox"/> Sonstiger Unfall		
Bei Kindern unter einem Jahr sowie bei Totgeburten		Mehrlingsgeburt? <input type="checkbox"/> ja <input type="checkbox"/> nein Länge bei Geburt: cm Geburtsgewicht: g		
Bei Neugeborenen, die innerhalb der ersten 24 Stunden verstorben sind		Frühgeburt in der Schwangerschaftswoche Lebensdauer in vollendeten Stunden: Stunden <input type="checkbox"/> unbekannt		
Bei Frauen		Liegt eine Schwangerschaft vor? <input type="checkbox"/> ja, im -ten Monat <input type="checkbox"/> nein <input type="checkbox"/> unbekannt Erfolgte in den letzten 42 Tagen eine Entbindung, eine Interruptio, ein Abort oder eine Extrauterin gravidität? <input type="checkbox"/> ja <input type="checkbox"/> nein <input type="checkbox"/> unbekannt Erfolgte zwischen dem 43. Tag und dem Beginn des letzten Jahres vor Todeseintritt eine Entbindung, eine Interruptio, ein Abort oder eine Extrauterin gravidität? <input type="checkbox"/> ja <input type="checkbox"/> nein <input type="checkbox"/> unbekannt		
Ärztliche Bescheinigung				
Auf Grund der von mir sorgfältig und an der unbedeckten Leiche durchgeführten Untersuchung bescheinige ich hiermit den Tod und die oben genannten Angaben.				
Ort, Datum und Zeitpunkt der Leichenschau		<div style="text-align: right;">Unterschrift und Stempel der Ärztin/des Arztes</div>		

Blatt 1: Gesundheitsamt		Todesbescheinigung – Vertraulicher Teil 2 –		(gelb)
Personalangaben				
Name ggf. Geburtsname, Vorname				
Straße, Hausnummer				
PLZ, Wohnort, Landkreis				
Geburtsdatum	Tag	Monat	Jahr	Geburtsort
Sterbezeitpunkt, ggf. Datum der Leichenauffindung	Tag	Monat	Jahr	Uhrzeit: Stunden Minuten
				Geschlecht: <input type="checkbox"/> männlich <input type="checkbox"/> weiblich
<p>Der vertrauliche Teil 2 der Todesbescheinigung gibt der Ärztin/dem Arzt die Möglichkeit, ergänzende Anhaltspunkte für einen nicht natürlichen Tod anzuführen und ergänzende Angaben zur Todesursache bzw. zu Begleiterkrankungen (Epikrise) zu machen. Bei Ausfüllen des vertraulichen Teils 2 bitte im vertraulichen Teil 1 ankreuzen, dass weitere Angaben gemacht werden. Auch der vertrauliche Teil 2 ist unter Angabe von Ort, Datum und Zeitpunkt der Leichenschau von der Ärztin/dem Arzt zu unterschreiben.</p> <p style="text-align: center;">Der vertrauliche Teil 1 ist in jedem Falle vollständig auszufüllen!</p> <p>Anhaltspunkte für einen nicht natürlichen Tod</p> <div style="border: 1px solid black; height: 150px; width: 100%;"></div> <p>Ergänzende Angaben zur Todesursache und zu Begleiterkrankungen (Epikrise)</p> <div style="border: 1px solid black; height: 150px; width: 100%;"></div>				
<div style="display: flex; justify-content: space-between;"> <div style="width: 30%;"> <p>Ärztliche Bescheinigung</p> <div style="border: 1px solid black; height: 40px; width: 100%;"></div> <p style="font-size: small;">Ort, Datum und Zeitpunkt der Leichenschau</p> </div> <div style="width: 65%;"> <p>Auf Grund der von mir sorgfältig und an der unbedeckten Leiche durchgeführten Untersuchung bescheinige ich hiermit den Tod und die oben genannten Angaben.</p> <div style="border: 1px solid black; height: 40px; width: 100%;"></div> <p style="text-align: right; font-size: small;">Unterschrift und Stempel der Ärztin/des Arztes</p> </div> </div>				

Source: Freistaat Bayern Todesbescheinigung, Information für die Ärztin/den Arzt,
http://www.blaek.de/pdf_rechtliches/extra/todesbe.pdf

Every death in Germany has to be announced to the local Civil Registry Office by a certified person at latest the next working day after the occurrence of death. The event is then recorded by an officer in the death-records registry (*Sterbebuch*). The burial can only take place after registration in this registry.

As for the demographic information about the deceased, the civil registry officer enters into the statistical counting card (*Sterbefallzählkarte*) the following information about the death:

- date of death, the sex, age, marital status, and place of residence of the deceased;
- occupational status of the deceased, legal membership/non-membership in a church, religion, citizenship;
- age of the surviving partner (for married persons);
- cause of death and duration of life in hours, if the death occurred within the first 24 hours of life.

The counting card is then sent on to the Regional Statistical Office (*Statistisches Landesamt*) at least on a monthly basis. Upon the reception of a filled in death certificate and after having recorded the event in the death records registry, the registry officer sends the confidential part of the death certificate to the Health Office (*Gesundheitsamt*), where the medical data are exploited for the purposes of the office's tasks (e.g., the surveillance of epidemics) and the death certificate is checked and if necessary, corrected, for completeness and plausibility of the diagnostic information. Afterwards the Health Office transfers the death certificate to the Regional Statistical Office.

At the Regional Statistical Office, the causes of death, written by hand on the death certificate, are coded in the terms of the current ICD revision.³⁵ The majority of German coders are non-medical professionals (Giersiepen and Greiser 1989) who receive regular training on coding rules and changes in the coding instructions. The training is organized centrally (to assure data comparability between the Länder) and since recently has been organized by the Federal Statistical Office in cooperation with the DIMDI (*Deutsches Institut für Medizinische Dokumentation und Information*) on a yearly basis.³⁶ After the coding, the two sources of mortality information (the statistical bulletin and the death certificate) are combined, based on the death record registry number (*Sterbebuchnummer*). The confidential death certificate is then returned to the Health Office, where it is archived for several years, depending on the Bundesland.

Mortality statistics in Germany are based on the place of residence of the deceased. Therefore, before further processing, the certificates of deaths that occurred outside the residence region are exchanged between the Regional Statistical Offices (Bubenheim 2000). The latter then computerize the data and prepare statistics on regional mortality and cause of death. The country data, which we are using in the present study, are summarized from the regional tables.

If the medical doctor suspects a non-natural origin to the death (suicide, homicide, fall, poisoning etc.) or if the identity of the deceased is unknown, then police investigation is

³⁵ An exception to this model is Hamburg, where the causes of death are coded at the health office.

³⁶ Training materials can be found at www.dimdi.de.

required, making for substantial variation in the transmission of the death certificate in question between the Länder. In Bavaria, the medical doctor passes the certificate to the police, which forwards the filled out document directly to the registry office. In Baden-Württemberg, the doctor waits for the results of the police investigation and only then sends the death certificate to the registry office. In the most populated Land of Germany, North Rhine-Westphalia, the death certificate does not pass through the Civil Registry Office; when the inquiry has been answered, the certificate is sent by the medical doctor directly to the Health Office (Bubenheim 2000). As the final proportions of deaths in North-Rhine-Westphalia without a reported cause (ICD9 item 799) was remarkably elevated when compared to other regions, it is possible that the Land-specific regulations on death-certificate transmission biases the mortality statistics (Bubenheim 2000).

3.2.2 Czech Republic

The main entry for the cause-of-death statistics in the Czech Republic is the form named List o prohlídce mrtvého (see Figure 8).³⁷ The currently used form dates from 1964 and contains one line for immediate, one for antecedent and one for underlying cause of death (and therefore is not up-to-date with current WHO recommendations).³⁸

Every death occurring outside of health establishment has to be announced to the respective general practitioner without delay. The general practitioner, or the appointed physician of the health establishment, also usually performs the mandatory post-mortem examination, unless he treated the patient at the moment of his death. After the post-mortem examination, if autopsy was not indicated, the certifying practitioner fills in the death certificate (in four copies) and passes the filled form to the civil registry office. Both the administrative (name, date of birth, national identification number, marital status, education, place of residence, certifying practitioner) and the medical part, including the 4-digit ICD codes, are filled out by the certifying practitioner. The death certificate is not divided into confidential and non-confidential part; the protection of individual medical data in Czech Republic is assured only by the fact that the document is not public.

Upon the reception of the death certificate, the civil registry officer records the event in the vital registry and releases two documents: 1) the death report (Hlášení o úmrtí) for the CSO - Czech Statistical Office (ČSÚ – Český statistický úřad) containing all the reported diseases, and 2) the “death certificate” (Úmrtní list) for the bereaved - without mention of cause of death. One copy of the death certificate is archived at the vital registry office, the second one is transmitted to the IHIS - Institute of health information and statistics (ÚZIS – Ústav zdravotnických informací a statistiky), where it is copied into a death certificate information system and eventually used to link and complete the National Oncology Registry, to check the quality of the data, to perform additional analyses etc. (www.uzis.cz)

³⁷ It may be misleading that the English translation of List o prohlídce mrtvého would be Post-mortem examination certificate, while the Czech term equivalent to death certificate is used for another document released by the registry.

³⁸ Interestingly, the form used until 1964 also contained three lines, but in reversed order (the underlying cause of death was on the top line). This is an example of a compromise between the WHO recommendations and the Czech historical habit to report first the underlying disease.

The death reports are the unique source of mortality and cause-of-death statistics in the Czech Republic. They are sent to the CSO on a monthly basis. The selection and coding of the underlying cause of death is centralized and is also performed at the Czech Statistical Office; the coders are non-medical trained professionals. After the coding, the underlying cause of death is entered into a database, which is further transmitted to the IHIS.

Schematic representation of compilation of cause-of-death data is shown on Figure 7.

Figure 7 Schematic representation of cause-of-death data collection in the Czech Republic

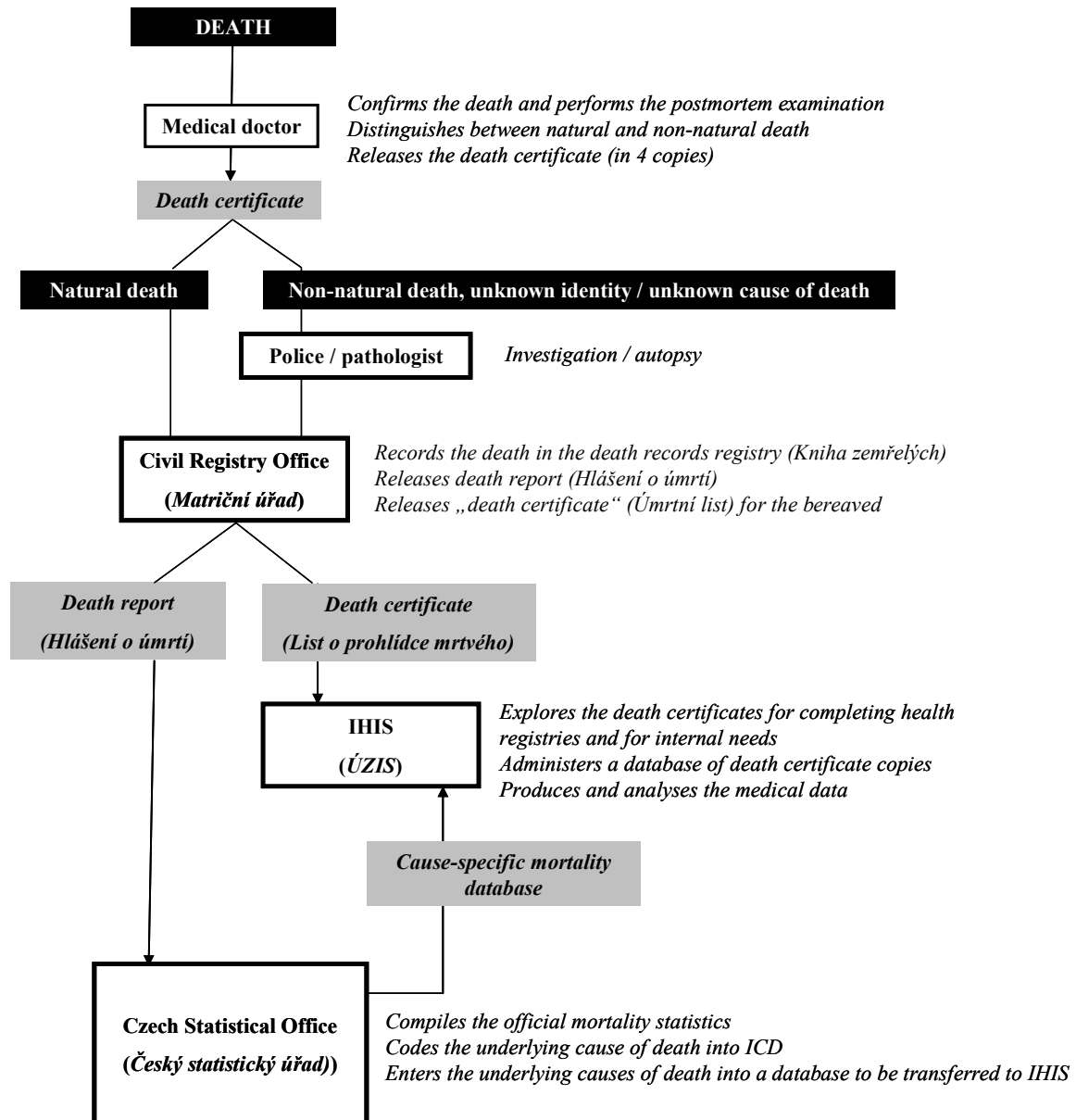


Figure 8 Death certificate valid in Czech Republic [List o prohlídce mrtvého]

Poř. č. svazek ročník

List o prohlídce mrtvého

Rok:
 Ošetřovací číslo:
 Číslo listu o prohlídce:
 Číslo pitvného protokolu:

1. Jméno: Příjmení: roz.:
 (Při změně jména nebo příjmení též jméno nebo příjmení dřívější)

2. Datum narození: rodné číslo: 3. Pohlaví:
 (u neznámých mrtvol přibližné stáří)

4. Rodinný stav: 5. Státní příslušnost: 6. Národnost:
 7. a) Zaměstnaní: b) Zaměstnavatel:
 c) Zdroj obživy: 8. Nejvyšší ukončené vzdělání:
 9. Rodiště: obec: ulice, číslo:
 okres: kraj (u cizinců stát):

10. Bydliště: obec: ulice, číslo:
 (u novorozenců bydliště matčino)
 okres: kraj (u cizinců stát):

11. a) Jméno a příjmení manžela (ky) i zemřelého (é): roz.:
 b) Datum narození manžela (ky): pokud žije, rodné číslo:
 12. Datum a místo uzavření manželství:
 13. Jméno a příjmení otce: pokud žije, rodné číslo:
 rodičů zemřelého: matka: roz.: pokud žije, rodné číslo:
 14. Datum úmrtí: 15. Jde o prohlídku mrtvé narozeného dítěte? Ano - ne
 (den, měsíc, rok - hodina) (nápadně zaškrtněte)

16. Místo úmrtí: 17. Kde nastalo úmrtí?
 (nález mrtvol) (adresa) (doma, v nemocnici, v léčebném ústavě, na ulici, při převozu apod.)

18. Kým, kde a od kdy byl zemřelý naposled léčen:

19. Příčina smrti (podle klinického nálezu)		Přibližná doba mezi začátkem onemocnění a smrtí	Znak Podrobného seznamu MKN
I.	Nemoc (stav), která(ý) přímo vedl(a) k smrti (bezprostřední příčina smrti **) Předchozí příčiny, tj. chorobné stavy, jsou-li jaké, které způsobily stav uvedený pod a), prvotní příčina (základní nemoc, hlavní nemoc) se uvede nakonec pod c)	a) b) c)
II.	Jiné závažné chorobné stavy nebo změny, spolupodmiňující smrt, které nebyly v příčinné souvislosti s nemocí nebo stavem uvedeným pod I. a)

**) To neznamená, že způsob smrti (např.: srdeční selhání, asténie, apod.), nýbrž nemoc, úraz nebo komplikaci, které způsobily smrt.

20. Šlo o přenosnou nemoc? Ano - ne 21. Šlo o nemoc z povolání? Ano - ne
 22. Šlo o pracovní úraz, náhodný úraz, vraždu, sebevraždu?
 (zaškrtněte a uveďte mechanismus smrti, např. pád z výše, oběšení, přejetí vlakem, zabiti zvířetem, přejetí traktorem apod.)

Snímatelné ozdoby nebo protézy z drahých kovů

23. a) U dětí: 1. mrtvé narozených
 2. zemřelých
 do 1 roku: zralé - nezralé (zaškrtněte)
 do 24 hodin po porodu: délka života v hod.:
 do 15 let: rodiče manželé? Ano - ne (zaškrtněte)
 Má matka výdělečné povlání a jaké?

b) U zemřelých žen: počet živě narozených dětí:

24. Návrh prohlížečského lékaře:
 (návrh k pitvě, zdravotně bezpečnostní opatření, lhůta a způsob pohřbu)

V dne
 (místo prohlídky) (den, měsíc, rok - hodina prohlídky)

.....
 Razítko a podpis ošetřujícího lékaře

.....
 Razítko a podpis prohlížečského lékaře

SEVT 14 105 0 02/855 17 11 I/99 Tisk: EPAVA, 068/531 26 66

25. Závěrečná diagnóza po provedení pitvy		Přibližná doba mezi začátkem onemocnění a smrtí	Znak Podrobného seznamu MKN
I.	Nemoc (stav), která(ý) přímo vedl(a) k smrti (bezprostřední příčina smrti) **)	a)
	Předchozí příčiny, tj. chorobné stavy, jsou-li jaké, které způsobily stav uvedený pod a),	b)
	prvotní příčina (základní nemoc, hlavní nemoc) se uvede nakonec pod c)	c)
II.	Jiné závažné chorobné stavy nebo změny, spolupodmiňující smrt, které nebyly v příčinné souvislosti s nemocí nebo stavem uvedeným pod I. a)

**) To neznamená způsob smrti (např. : srdeční selhání, asténie, apod.), nýbrž nemoc , úraz nebo komplikaci, které způsobily smrt.

20. Šlo o přenosnou nemoc? Ano - ne	21. Šlo o nemoc z povolání? Ano - ne
22. Šlo o pracovní úraz, náhodný úraz, vraždu, sebevraždu? (zaškrtněte a uveďte mechanismus smrti, např. pád z výše, oběšení, přejetí vlakem, zabít zvířetem, přejetí traktorem apod.)	

V dne
(místo pitvy) (den, měsíc, rok - hodina pitvy) Razítko a podpis pitvajícího lékaře

Povolení pohřbu žehem

Datum pohřbu: Místo pohřbu: Proti pohřbu žehem jsou - nejsou námitky.

V dne
Razítko okresního úřadu V dne
Razítko (podpis) okres. odděl. min. vnitra, odděl. policie ČR

Povolení převozu k pohřbení

Povoluje se pod čj. ze dne převoz do:
V dne
Hlášeno k zápisu do matriky dne:
Razítko okresního úřadu

Výkaz pro ČSÚ vyhotoven dne: a odeslán dne:

Úmrtní list a žádost o pohřebné vydány dne:
V dne
Razítko a podpis matrikáře

POUČENÍ

Prohlízející lékař vyplní a podepíše list trojmo, byl-li mrtvý ošetřován jiným lékařem než prohlízejícím, vyplní a podepíše diagnostickou část listu ošetřující lékař, v pochybnostech o příčině smrti po poradě s odborným lékařem.

Jestliže prohlízející lékař byl zároveň ošetřujícím lékařem, musí podle § 3 odst. 1 vyhl. MZd. č. 47/1966 Sb. provést prohlídku zemřelého jiný oprávněný prohlízející lékař, který vyplní a podepíše list. Byla-li provedena pitva, není nutné pro účely pohřbu včetně pohřbu žehem potvrzení ošetřujícího lékaře.

Úmrtí oznámí ošetřující lékař doručením všech tří vyhotovení matrikářů příslušnému podle místa úmrtí, nebo nálezů mrtvol nejpozději následujícího dne po úmrtí. Má-li být mrtvola pitvána mimo matriční obvod, doručí prohlízející lékař matrikářů nejprve "Předběžné oznámení úmrtí" (č. skl. 14 168 0) a odešle trojmo vyplněný list s mrtvolou k pitvě. Pitvající lékař po pitvě odešle dvě vyhotovení matrikářů příslušnému podle místa úmrtí. Jedno vyhotovení vydá obstaravateli pohřbu.

List musí být vyplněn čitelně ve všech rubrikách, jména a diagnózy musí být vyplněny strojem nebo hůlkovým písmem.

Lékařské potvrzení, povolení k pohřbu žehem a povolení převozu k pohřbení, obsažené na listu, nahrazují zvláštní lékařská vyjádření a povolení z hlediska lékařského, potřebná k pohřbu žehem nebo k převozu mrtvého.

K jednotlivým rubrikám:

7. Pod písmenem a) zaměstnání a b) zaměstnavatel uvádějte vždy údaje o zemřelém nebo jeho živiteli, u důchodců jejich poslední zaměstnání a zaměstnavatele. Zaměstnání vyplňte co nej přesněji (např. havíř, prodáváč, frézář, učitel, průvodčí, chovatel drůbeže, traktorista).

Zaměstnavatele uveďte podle škály: státní sektor, ZD, ostatní družstva, samostatné hospodářství, svobodná povolání.

Zdroj obživy zemřelého uveďte podle škály: výdělečně činný, závislý na výděl. činném (manželka a dom., dětí), důchodce, závislý na důchodci.

8. Nejvyšší ukončené vzdělání uveďte (jen u osob starších 15 let) v jedné ze čtyř skupin: základní (včetně nedokončeného), střední bez maturity (včetně vyučen), střední s maturitou, vysokoškolské.

15. Prohlídku mrtvé narozeného dítěte odlište od prohlídky zemřelé osoby nápadným zaškrtnutím slova "Ano". Mrtvé narozené dítě je mrtvý plod narozený po 28 týdnech těhotenství. Nelze-li určit délku těhotenství v týdnech, je rozhodující hmotnost plodu. Mrtvý plod s hmotností 1000 g nebo více se považuje za mrtvé narozené dítě. Plod lehčí než

1000 g je potrat a list se na něj nevystavuje. Při ukončení těhotenství s více plody, z nichž alespoň jeden má znaky živého nebo mrtvého dítěte, musí být všechny plody hlášeny jako narozené děti.

16. Místo úmrtí je adresa místa úmrtí nebo nálezů mrtvol.

18. Byl-li zemřelý léčen v nemocnici, uveďte na kterém oddělení.

19. V části II. je uvedena posloupnost kauzálně spojených stavů, které vedly přímo k smrti, a to tak, že na prvním místě je bezprostřední příčina smrti, na posledním místě pod c) pak prvotní příčina smrti, tj. nemoc nebo zranění, jímž začal řetěz chorobných jevů vedoucích k smrti.

Prvotní příčina je určena pro statické zpracování a proto je též nemocí hlavní, tj. nejzávažnější.

V části II. se uvádějí další nemoci, které měly také, ale menší měrou, vliv na letální ukončení nemoci, jestliže hlavní posloupností přímo nesouvisí.

Příklady vyplnění:

- I. a) Infarkt myokardu
b) -
c) Skleróza tepen věnicových
II. Chronická bronchitida
- I. a) Septikémie
b) Gangréna
c) Diabetes
II. -
- I. a) Krvácení do mozku (cévního původu)
b) Sekundární hypertenze při arterioskleróze
c) Célová arterioskleróza
II. -
- I. a) Akutní nekróza jater
b) Cirhóza jater
c) Infekční zánět jater
II. Ischemická fibróza myokardu

22. Po zaškrtnutí druhu vnější příčiny smrti uveďte ještě podrobně mechanismus smrti, aby bylo umožněno zpracování podle dodatkové klasifikace v n e j š í ch příčin poranění a otrav "E".

25. Závěrečná diagnóza po provedení pitvy je určena s přihlédnutím k vyšetření, anamnéze a ostatním zjištěním za života nemocného i k výsledkům pitvy a dalších vyšetření po smrti. Pro vyplnění platí poučení u bodu 19.

28. Viz poučení u bodu 22.

3.2.3 France

In France, as was described in (Vallin and Meslé 1988), the death has to be announced by the family of the deceased at the vital registry office. In order to obtain the funeral permission at the registry office, the death has to be confirmed by the certifying practitioner, who delivers a death certificate (*certificat de décès*).

The vital registry officer registers the death record (*acte de décès*) into the vital-record registry (*registre d'état civil*). The family fills in the death bulletin (*bulletin de décès*), and then upon the reception of the death certificate, the funeral permission is issued.

Similarly as in West Germany, the cause-of-death statistics in France is thus compiled from two sources: socio-demographic information comes from the anonymous death bulletin filled by the relatives, while confidential medical information comes from the death certificates. These two sources are, as in West Germany, compiled via the vital-registry death record number.

The death certificate has two parts, the first one contains only the name of the deceased and time of death, the second one, containing confidential medical information, is anonymous and is transmitted to the vital registry office sealed by the certifying practitioner. The vital registry officer separates the two parts of the death certificates and attaches the sealed part to the death bulletin. Next, based on death bulletin he releases the death report (*avis de décès*) to inform the statistical office about the event. *Avis de décès* (death report) contains the same socio-demographic information as the bulletin, but unlike for the anonymous bulletin is nominative.

The death certificates coupled with death bulletins are transmitted to the DDASS (*Direction départementale des Affaires sanitaires et sociales*), where certified medical doctor opens the confidential part and exploits it for local surveillance of epidemics or other specific purposes. A copy of the received documents must be sent to INSERM (*Institut National de la Santé et de la Recherche Médicale*) (National Institute of Health and Medical Research), where the cause of death is encoded into the terms of current ICD revision, the codes are reported into the appropriate cases reserved for them on the death bulletin, and the original of the death certificate is destroyed. Meanwhile, the INSEE (*Institut National de la Statistique et des Études Économiques*) (National Institute of Statistics and Economic Studies) compiles the electronic database of socio-demographic indicators from the death reports. This database is then transferred to INSERM, where the cause-of-death codes are added. The national mortality statistics are compiled from this database.

In 1999, the system underwent several updates. First of all, a new death certificate has been put in place (in 1997) to comply with the current recommendations of WHO (recently there are therefore two separate death certificates for adults and infants with four lines to report the train of diseases leading to death). Second, an automated coding has been introduced to facilitate the work with the 10th ICD revision, which is considerably larger than previous revisions, and third, the death certificates are archived in an electronic form for further retrieval of information. The death certificate used prior to 1997 is shown at Figure 9, the new form is shown at Figure 10. The schematic representation of the cause-of-death data collection in France as described here is shown at Figure 11.

Figure 9 Death certificate used in France prior to 1997

DEPARTEMENT

CERTIFICAT DE DÉCÈS

(Partie à détacher
et à conserver dans les Mairies)

A remplir par le Médecin

COMMUNE :

NOM

Prenoms

Age

Domicile

Le Docteur en médecine soussigné, certifie que la mort de la personne désignée ci-contre, survenue

le à heure

est réelle et constante.

La cause est indiquée dans le document confidentiel ci-joint qui ne doit être ouvert que par le Médecin de la Santé Publique attaché à la Direction départementale des Affaires sanitaires et sociales.

A le

Signature

RÉSERVE À LA MAIRIE

Le numéro d'ordre du décès sur le registre des actes de l'état civil à inscrire ci-contre, doit être reproduit au verso.

N° D'ORDRE
du décès

A remplir et à clore par le Médecin

COMMUNE

DATE DU DÉCÈS

Renseignements confidentiels et anonymes sur la cause du décès

I. — Cause du décès

a) Cause immédiate de la mort

(Nature de l'évolution terminale, de la complication éventuelle de la maladie, ou nature de la lésion fatale en cas d'accident ou d'autre mort violente) (1).

qui est consécutive à :

b) Cause initiale

(Nature de la maladie causale ou de l'accident, du suicide, ou de l'homicide.)

II. — Renseignement complémentaire

Etat morbide (ou physiologique, grossesse par exemple) ayant contribué à l'évolution fatale (mais non classable en) comme cause proprement dite du décès(2).

Une autopsie a-t-elle été pratiquée?

OUI

NON

(3)

NOTE

Signature ou cachet du médecin.

Ce document qui ne peut être communiqué ni en original, ni en copie, sera détruit par les soins du médecin chargé d'établir la statistique des causes de décès dès qu'il y aura puise les renseignements indispensables pour cette statistique.

(1) Mentionner ici le cas échéant le décès post-opératoire

(2) Mentionner ici le cas échéant l'état mental pathologique qui a pu être à l'origine du suicide

(3) Rayer la mention inutile

EXEMPLES

Décès par maladie	Décès par accident	Décès par suicide	Décès par homicide
I. a) Broncho-pneumonie b) Rougeole	I. a) Fracture du crâne b) Chute dans un escalier	I. a) Plais du cœur par balle b) Suicide par arme à feu	I. a) Section de l'artère fémorale b) Homicide par coup de couteau
II. Rachitisme	II. Éthylisme chronique	II. Etat mélancolique	

Source: (Vallin and Meslé 1988)

Figure 10 Death certificate used in France since 1997

DÉPARTEMENT : _____

CERTIFICAT DE DÉCÈS
conforme à l'Arrêté du 24 décembre 1996

A remplir par le Médecin

COMMUNE DE DÉCÈS : _____
Code Postal : _____

NOM : _____
Prénoms : _____
Date de naissance : _____
Domicile : _____

Le docteur ci-dessus désigné, certifie que la mort de la personne désignée ci-contre, est survenue à _____ heure _____ est réelle et

Obstacle médico-legal (voir 2 au verso) ☐ OUI ☐ NON
Obstacle médical en bière immédiate (voir 3 au verso) ☐ OUI ☐ NON
Obstacle au don du corps (voir 6 au verso) ☐ OUI ☐ NON
Prélèvement en vue de rechercher la cause du décès (voir 7 au verso) ☐ OUI ☐ NON
Présence de prothèse fonctionnant au moyen d'une pile (voir 8 au verso) ☐ OUI ☐ NON

Important : bien cocher toutes les lignes par oui ou non

RÉSERVÉ À LA MAIRIE
Le numéro d'ordre du décès sur le registre des actes de l'état civil à inscrire ci-contre doit être reproduit au verso.

N° D'ORDRE du décès
| | | | |

A _____ le _____
Signature (Nom lisible) et Cachet (obligatoire) du médecin

A conserver dans la mairie du lieu d'implantation de la chambre funéraire

A remplir et à clore par le Médecin
Renseignements complémentaires et annexes

Code Postal : _____ Commune de décès : _____ Date de décès : _____
Code Postal : _____ Commune de domicile : _____ Date de naissance : _____

1. Sexe masculin
2. Sexe féminin

Causes du décès

PARTIE I Maladie(s) ou affection(s) morbide(s) ayant directement provoqué le décès*
La dernière ligne remplie doit correspondre à la cause initiale.

a) _____
due à ou consécutive à : b) _____
due à ou consécutive à : c) _____
due à ou consécutive à : d) _____

* Il s'agit de la maladie, du traumatisme, de la complication, ou d'un événement entraînant la mort (et non du mode de décès, ex. : syncope, arrêt cardiaque...)

PARTIE II Autres états morbides, facteurs ou états physiologiques (grossesse...) ayant contribué au décès, mais non mentionnés en Partie I

Informations complémentaires

Le décès est-il survenu pendant une grossesse (à déclarer, même si cet état n'a pas contribué à la mort) ou moins d'un an après ? 1. Oui 2. Non
Dans ce dernier cas, intervalle entre la fin de cette grossesse et le décès : Mois _____ Jours _____

En cas d'accident, préciser le lieu exact de survenue (voie publique, domicile...) : _____ S'agit-il d'un accident du travail (ou présumé tel) ? :
1. Oui 2. Non 3. Sans précision

Autopsie : une autopsie a-t-elle été ou sera-t-elle pratiquée ? 1. Non 2. Oui, résultat disponible 3. Oui, résultat non disponible

Lieu du décès :
1. Domicile 2. Hôpital 3. Clinique privée
4. Hospice, maison de retraite 5. Voie publique 6. Autre lieu

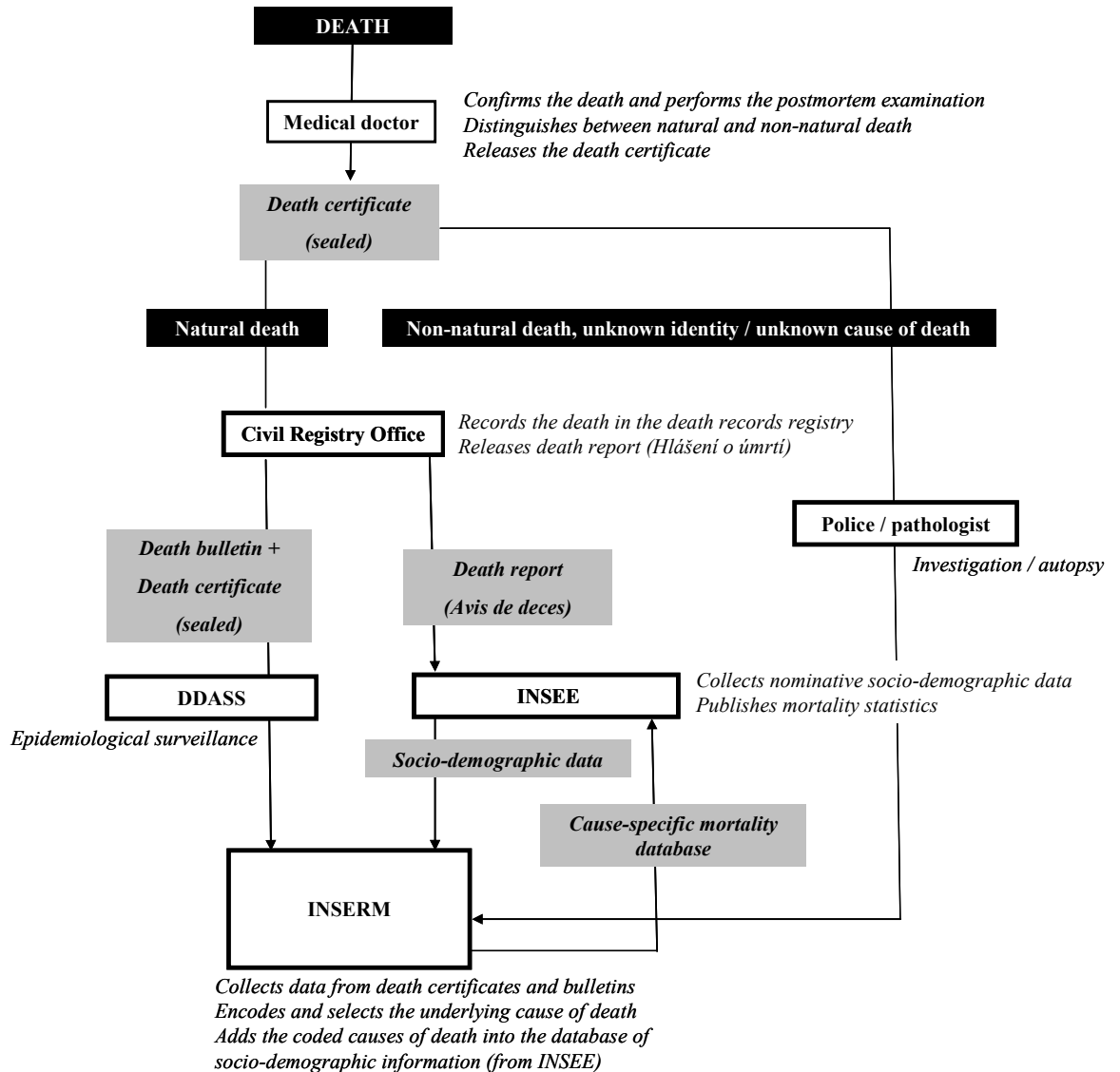
Signature (Nom lisible) et Cachet (obligatoire) du médecin

Exemples

	Intervalle		Intervalle		Intervalle
I. a) Septicémie	9.6	E. a) Cause	17.8	I. a) Hémostase anormale	1.6
b) Polémie	19.1	b) Oedème cérébral	19.9	b) Hypertension	19.9
c) Perturbation d'achète	1.7	c) Transfusion erronée	2.7	c) Anémie	1.7
d) Ulcère gastroduodénal	1	d) Accident de la route	2.7	d) Cancer du site initial	-
II. Alcoolisme	-				
I. a) Emphyseme chronique	20.7	E. a) Strabisme	-	I. a) Diabète respiratoire	5 ans
b) SIDA	7.9	b) Sclérose	-	b) Tumeur pulmonaire	3 ans
c) -	-	c) -	-	c) Phéochromocytome	7
d) -	-	d) -	-	d) Anesthésie	28.7
II. Rapet, Tuberculose	-	II. Tétanos	-	B. Vénère	-

Ce document ne peut être communiqué à quiconque si ce n'est à la police, si ce n'est à la justice

Source: http://www.cepidc.vesinet.inserm.fr/inserm/html/pdf/Cert_DC.pdf

Figure 11 Schematic representation of cause-of-death data collection in France

Chapter III.

Transition between ICD8 and ICD9

4.1 Collected data

4.1.1 West Germany

The data were extracted from two types of sources: for the 1968-1979 period, they were computerised from the printed statistics on causes of death, while since 1980 the data have been provided in electronic format. The collected data are inconsistent with respect to the age scale, the level of classification detail, the classification of causes of death, and possibly other barely traceable inconsistencies in the quality of cause-of-death registration.

Table 6 provides a summary of the data collected by the MPIDR for the purpose of reconstructing continuous time series of mortality by cause of death in West Germany. The time period between 1968 and 1978 is covered by ICD8. The data on the causes of death are presented in the form of a short list comprising a mixture of single 3-digit items, selected 4-digit items, and groups of either 3-digit or 4-digit items, or both. There is a substantial difference between the tabulation detail in the first year and the following years of the ICD8, while the number of 4-digit codes increased from 10 in 1968 to 157 in 1969. In order to obtain the same level of detail for 1968 as for the other years, the deaths from the 1968 items without sufficient detail were redistributed according to the proportions observed in 1969 and 1970.

The 9th revision of the ICD was applied to West German cause-of-death statistics in 1979. The data available in the printed version in 1979 are similar in structure and detail to those of ICD8, i.e. a mixture of single 3-digit codes and 4-digit codes. As of 1980, the Federal Statistical Office started to tabulate the cause-of-death data in electronic format. Once again, in order to overcome the differences in the published detail, we redistributed the deaths of 1979 classified in groups proportionally to the 3-digit level structure observed in 1980 and 1981. The 892 3-digit items and the 5-year age structure of the electronic data thus match the structure of the reconstructed time series.

Table 6 Summary information on causes of death for West Germany, as provided by the Federal Statistical Office (1968-1997)

Period	ICD	Number of items	List	Age group format	Data type
1968	ICD8	111	Groups of 3-digit and 4-digit items	0-23 hrs, 24 hrs - 6 days, 7-27 days, 28 days-1 year,	Printed data
		337	3-digit items	1-4, 5-9, 10-14, ..., 85-89, 90+, unknown (incl. distinction of deaths in/outside of institutions)	
		10	4-digit items		
1969 -1978	ICD8	111	Groups of 3-digit and 4-digit items	0-23 hrs, 24 hrs - 6 days, 7-27 days, 28 days-1 year,	dtto
		337	3-digit items	1-4, 5-9, 10-14, ..., 85-89, 90+, unknown (incl. distinction of deaths in/outside of institutions)	
		157	4-digit items		
1979	ICD9	104	Groups of 3-digit and 4-digit items	0-23 hrs, 24 hrs - 6 days, 7-27 days, 28 days-1 year,	dtto
		299	3-digit items	1-4, 5-9, 10-14, ..., 85-89, 90+, unknown (incl. distinction of deaths in/outside of institutions)	
		130	4-digit items		
1980-1997	ICD 9	892	3-digit items	0, 1-4, 5-9, 10-14, ..., 85-89, 90+, unknown	Electronic data

Note: The "Number of items" column refers to natural causes of death (001-799) and to the E-classification (E800-E999). We do not work with the N-classification of external causes of death.

4.1.2 Czech Republic

Since January 2006, detailed (3-digit ICD level) cause-of-death data since 1919 are available at the Czech Statistical Office (CSO) web site.³⁹ However, by the time we launched the reconstruction (around 2003), we only had access to electronic data after year 1992. The previous data (for years 1968-1991) were therefore computerized from printed data published in the series "*Pohyb obyvatelstva v republice Československé (Československé socialistické republice, České socialistické republice, České a Slovenské Federativní republice)*".

The data covering ICD8 have been published under unique list of 857 items, divided by sex and 22 age groups, without the age-specific detail after age 85. This age group format went unchanged under ICD9.

During the first seven years of ICD9 period, the collected data were classified under 911 3-digit items. Until 1985 three items, which ICD does not allow as mortality codes, regularly appeared in the mortality statistics: items 196, 197 and 198. Since 1986 all these deaths have - most probably - been attributed to ICD9 item 199.⁴⁰ Moreover, since 1986, only the non-zero mortality items were published, which reduced the published list by almost a half. In 1989, first cases of death from HIV infections appeared in the Czech statistics. After standardizing for unique list, the reconstructed data for Czech Republic thus contain 912 3-digit ICD9 items. If we do not consider the codes 196-198, only 909 ICD9 items are available.

³⁹ [http://www.czso.cz/csu/2007edicniplan.nsf/publ/4017-07-\(1919_az_2006\)](http://www.czso.cz/csu/2007edicniplan.nsf/publ/4017-07-(1919_az_2006))

⁴⁰ We dealt with this issue in the frame of the corrections a posteriori.

Table 7 Summary information on causes of death for Czech Republic

Period	ICD	Number of items	List	Age group format	Data type
1968-1978	ICD8	857	3-digit items	0, 1, 2, 3, 4, 5-9, 10-14, ..., 85+	Printed data
1979-1985	ICD9	911	3-digit items	0, 1, 2, 3, 4, 5-9, 10-14, ..., 85+	Printed data
1986-1991	ICD9	475-505 *	3-digit items	0, 1, 2, 3, 4, 5-9, 10-14, ..., 85+	Printed data
1992-1993	ICD9	471,480 *	3-digit items	0, 1, 2, 3, 4, 5-9, 10-14, ..., 85+	Electronic data

Note: As in the previous case, the “Number of items” column refers to natural causes of death (001-799) and to the E-classification (E800-E999). We do not work with the N-classification of external causes of death. Until 1991 the E-classification was published along with other codes (001-999) in table G 06, since 1992 the E-classification and the rest of the causes are published separately as tables G 05 and G 06.

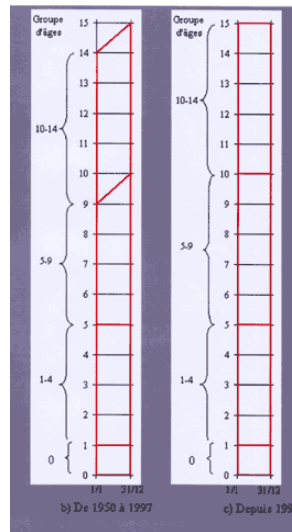
* As of 1986, the Czech Statistical Office did not publish ICD items with 0 mortality.

4.1.3 France

The cause-of-death data for the third country in our comparison have been previously reconstructed by France Meslé and Jacques Vallin from Institut national d'études démographiques, who kindly provided their database for our research. The reconstruction (and the mortality trends) were exhaustively described in Vallin and Meslé (1988) for ICD8, and the work went on with transition to ICD9 a few years later (Meslé and Vallin 1993; Meslé and Vallin 1996). Eventually, the reconstructed series since 1925, along with documentation, have been published online at the web site of INED.⁴¹

Out of the three countries, the data for France are the most detailed by both classification and age group format – they provide the 4th digit detail and the data are divided into 5-year age groups up to the open interval 105+. They are also the longest in time, while France was the latest to adopt ICD10 – it did so only in 2000. Due to a different system of vital records, the French data have different age group structure than is usual: up to 1997, only the age group 0 and 1-4 years was classified in the Lexis square (by completed age and year of death). The age group then 5-9 gathered all deaths at completed ages 5 to 9 years plus deaths occurred in the same year to the generation attaining its 9th birthday during the year of observation. Since 1998 the French cause-of-death system has entirely been based on the completed age and period (Lexis squares). Our ICD9 data, however, as well as the population counts, have been recalculated to suit the system in use between 1950 and 1998.

⁴¹ http://www.ined.fr/fr/ressources_documentation/donnees_detaillees/causes_de_decès_depuis_1925/

Figure 12 Schematic representation of the French cause-of-death data age group formats

Source: www.ined.fr

4.2 Reconstruction of the time series

4.2.1 West Germany

In West Germany, similarly to the majority of European countries, no double classification was produced at the time of change from the 8th to the 9th ICD revision. This lack of information led to the application of a method developed for the purpose of reconstructing time series in France for years 1925-1978, based on the creation of an *ex-post* double classification (Vallin and Meslé 1988). The method comprises three steps. First, a table of mutual correspondences between the medical content of each item of the two successive ICD revisions is created. Based on these correspondences, a list of elementary associations with identical medical and statistical content is created. The elementary associations then serve as a framework for estimating transition coefficients – the proportions of exchange between the linked ICD items from the old and the new cause-of-death classifications. At each step, the resulting series must be examined carefully.

Correspondence tables

When the 9th ICD revision was updated, WHO did not publish a document describing the changes in the classification and suggesting the correspondences. Consequently, the correspondence tables have to be constructed by systematic comparison of the analytic tables and alphabetic indexes of the two respective classifications. The Statistical Office in West Germany created a hypothetical correspondence table adapted to the needs of the German tabulation system,⁴² which served as a basis for our work.⁴³ However, many of these correspondences later proved to be insufficient, requiring large modifications.

⁴² A machine-typed document entitled Umsteigeschlüssel für die Klassifikationen ICD 8. und 9. Revision, Statistisches Bundesamt, VII D, Wiesbaden, the 6th December 1982.

⁴³ At this point, we would like to thank Dr. Michael Bubenheim, who constructed the very first version of the correspondence tables and of the elementary associations.

A correspondence table consists, in fact, of two reciprocal tables – the first one assigns to each item of ICD9 all items of the ICD8 which have at least a part of the medical content in common. The second table then lists all mutual correspondences again, sorted by ICD8 items. Table 8 and Table 9 show a subset of the correspondence table between ICD8 and ICD9.

Elementary associations

The idea behind the so-called elementary associations is to create the smallest possible clusters of deaths by the same causes. Elementary associations combine information from the correspondence table (theoretical content) with the reported numbers of deaths in the transition years (empirical content). This approach guarantees both medical and statistical continuity.

There are several types of associations, depending on the complexity of the changes between the two successive ICD revisions. In the easiest case, one ICD9 item corresponds to only one ICD8 item (and *vice versa*), suggesting that no change in the definition took place between the two revisions. As the classification becomes more detailed with the next revision, many of the elementary associations split one ICD8 item into multiple ICD9 items. In rather rare cases, several ICD8 items join to form a single ICD9 item.⁴⁴ Obviously, splitting and joining means that only the classification detail has changed. In cases other than change of detail, the resulting associations are complex, linking several related ICD9 and ICD8 items.

Table 10 shows all the elementary associations that come out of the ICD items listed in Table 8 and Table 9. Each association contains information to identify the cause of death in question (ICD9 code and title), the identification of the corresponding items (ICD8 code and title), the death counts before and after the transition year, and the portion of each ICD8 item which corresponds to its ICD9 counterpart. The portion is designated as T (total) or P (partial), with T meaning that the entire content of the ICD8 item will be associated with its ICD9 equivalent. If P is indicated, the ICD8 item will be split into several ICD9 items.

ICD9 item 410, *Acute myocardial infarction*. The next step is to search the ICD8 to ICD9 correspondence table for other possible links of ICD8 item 410. If no such links are found, and if the association is statistically balanced, the elementary association of type 1:1 can be closed (see Table 10 Association 141 and Association 143).

ICD9 item 403, *Hypertensive renal disease*, links with two ICD8 items: 403, *Hypertensive renal disease*, and 4003, *Malignant hypertension with renal involvement*. ICD8 contained a 3-digit code for malignant hypertension (400), specifying the affected organ system on the 4th digit detail (heart, renal, cerebrovascular, etc.). In ICD9 this concept of malignant hypertension was abandoned. There is no obvious equivalent of ICD8's malignant hypertension in ICD9, instead it links mainly to the new ICD9 items for hypertensive (401-405) and cerebrovascular (430-438) diseases.

⁴⁴ Such loss of classification detail on the 3-digit level was observed, for example, for a virtually eradicated disease: ICD9 item n° 002, *Typhoid and paratyphoid fever*, which covered two items in ICD8: item n° 001, *Typhoid fever* and item n° 002, *Paratyphoid fever*. However, the distinction between these two was kept in ICD 9 on the 4-digit level.

Table 8 Selected items of the correspondence table between ICD9 and ICD8

ICD9 items		ICD8 items	
Code	Title	Code	Title
402	Hypertensive heart disease	400.1	Malignant hypertension with heart involvement
		402	Hypertensive heart disease
		412	Chronic ischemic heart disease
403	Hypertensive renal disease	400.3	Malignant hypertension with renal involvement
		403	Hypertensive renal disease
...
410	Acute myocardial infarction	410	Acute myocardial infarction
...
412	Old myocardial infarction	412	Chronic ischemic heart disease
		414	Asymptomatic ischemic heart disease
		429	Ill-defined heart disease
413	Angina pectoris	413	Angina pectoris
414	Other forms of chronic ischemic heart disease	412	Chronic ischemic heart disease
		425	Cardiomyopathy
...
417	Other diseases of pulmonary circulation	426	Pulmonary heart disease
		44a	Remaining diseases of arteries, arterioles and capillaries
		441	Aortic aneurysm (nonsyphilitic)
...
425	Cardiomyopathy	425	Cardiomyopathy
		429	Ill-defined heart disease
...
429	Ill-defined descriptions and complications of heart disease	412	Chronic ischemic heart disease
		429	Ill-defined heart disease
...
442	Other aneurysm	44a	Remaining diseases of arteries, arterioles and capillaries
443	Other peripheral vascular disease	44a	Remaining diseases of arteries, arterioles and capillaries
...
446	Polyarteritis nodosa and allied conditions	44a	Remaining diseases of arteries, arterioles and capillaries
447	Other disorders of arteries and arterioles	44a	Remaining diseases of arteries, arterioles and capillaries
448	Disease of capillaries	44a	Remaining diseases of arteries, arterioles and capillaries

Table 9 Selected items of the correspondence table between ICD8 and ICD9

ICD8 items		ICD9 items	
Code	Title	Code	Title
400.1	Malignant hypertension with heart involvement	402	Hypertensive heart disease
...
400.3	Malignant hypertension with renal involvement	403	Hypertensive renal disease
...
402	Hypertensive heart disease	402	Hypertensive heart disease
403	Hypertensive renal disease	403	Hypertensive renal disease
...
410	Acute myocardial infarction	410	Acute myocardial infarction
...
412	Chronic ischemic heart disease	402	Hypertensive heart disease
		412	Old myocardial infarction
		414	Other forms of chronic ischemic heart disease
		429	Ill-defined descriptions and complications of heart disease
413	Angina pectoris	413	Angina pectoris
414	Asymptomatic ischemic heart disease	412	Old myocardial infarction
...
425	Cardiomyopathy	414	Other forms of chronic ischemic heart disease
		425	Cardiomyopathy
...
429	Ill-defined heart disease	412	Old myocardial infarction
		425	Cardiomyopathy
		429	Ill-defined descriptions and complications of heart disease
...
44a	Remaining diseases of arteries, arterioles and capillaries	417	Other diseases of pulmonary circulation
		442	Other aneurysm
		443	Other peripheral vascular disease
		446	Polyarteritis nodosa and allied conditions
		447	Other disorders of arteries and arterioles
		448	Disease of capillaries

Table 10 Examples of elementary associations**Association 141**

ICD9				ICD8		
Code	Title	Deaths in		Code	Portion	Title
		1979	1978			
410	Acute myocardial infarction	81121	79347	410	T	Acute myocardial infarction
	Sum	81121	79347			

Association 143

ICD9				ICD8		
Code	Title	Deaths in		Code	Portion	Title
		1979	1978			
413	Angina pectoris	1081	1024	413	T	Angina pectoris
	Sum	1081	1024			

Association 139

ICD9				ICD8		
Code	Title	Deaths in		Code	Portion	Title
		1979	1978			
403	Hypertensive renal disease	1222	1044	403	T	Hypertensive renal disease
			96	4003	T	Malignant hypertension with renal involvement
	Sum	1222	1140			

Association 153

ICD9				ICD8		
Code	Title	Deaths in		Code	Portion	Title
		1979	1978			
442	Other aneurysm	97	1100	44a	P	Remaining diseases of arteries, arterioles and capillaries (442, 443, 446-
443	Other peripheral vascular disease	935		44a	P	
446	Polyarteritis nodosa and allied conditions	78		44a	P	
447	Other disorders of arteries and arterioles	60		44a	P	
448	Disease of capillaries	18		44a	P	
(417)	(neglected)			(44a)	P	
	Sum	1188	1100			

Association 138

ICD9				ICD8		
Code	Title	Deaths in		Code	Portion	Title
		1979	1978			
402	Hypertensive heart disease	10693	9042	402	T	Hypertensive heart disease
			121	4001	T	Malignant hypertension with heart involvement
			55126	412	P	Chronic ischemic heart disease
412	Old myocardial infarction	1301		412	P	
			2	414	T	Asymptomatic ischemic heart disease
			1507	429	P	Ill-defined heart disease
414	Other forms of chronic ischemic heart disease	37473		412	P	
			378	425	P	Cardiomyopathy
429	Ill-defined descriptions and complications of heart disease	16861		412	P	
				429	P	
425	Cardiomyopathy	1036		425	P	
				429	P	
	Sum	67364	66176			

Note: In the "Portion" column, T stands for total correspondence, P for partial correspondence.

To create an elementary association, the first step is to search both of the correspondence tables. We find, for example, a single ICD8 item corresponding to a single ICD9 item, as with

Checking against the correspondence table ICD8/ICD9 (Table 9), the ICD8 items in question both link with ICD9 403 only, completing an association of type 1:N (see Association 139).

Due to the frequent grouping of ICD8 items in the West German tabulation system, many correspondences, which would possibly have been 1:1 if a full detail of the ICD8 had been published, were defined by splitting the grouped items into their ICD9 equivalents. The Association 153 represents such a case, when the ICD8 group 44a (containing items 442, 443 and 446-448) is split into 5 individual ICD9 items 442, 443, and 446-448.

Some correspondences are negligible enough to be dropped. In Association 153, in contrast to the correspondence tables, the link of ICD9 item 417 with ICD8 item 44a was neglected. We could do so under three conditions: 1) the major part of ICD9 item 417 was linked with another ICD8 item, 2) the link is assumed to be very marginal, and 3) the association remains statistically balanced.

Association 138 (Table 10) is complex (N:N type). In accordance with the correspondence table, the death counts of ICD8 item 402, *Hypertensive heart disease*, only partially compensate for the ICD9 item with the same number and title. As in the case of Association 139, a part of an ICD9 hypertensive disease is formed by the malignant hypertension of ICD8 (4001 - malignant hypertension with heart involvement). Another item brought to the association by the hypertensive heart disease of ICD9 is ICD8 item 412 *Chronic ischemic heart disease*. According to the ICD8 to ICD9 correspondence table, ICD8 item 412 links with three other ICD9 items: 412, 414, and 429. The correspondences of ICD9 item 412 bring ICD8 items 414 and 429 into the same association. Out of these, ICD9 item 414 also corresponds to ICD8 item 425, linked with another ICD9 item - 425 *Cardiomyopathy*. Apart from changes in the classification logic (as seen in malignant hypertension of ICD8), complex associations are thus mainly a mixture of splitting and joining several cross-linked ICD items.

Before proceeding to the next steps, the statistical continuity of each elementary association is checked and confirmed. We looked up the sums of all associations through the years 1968 to 1997. If the variation in the transition year exceeded the amplitude of a normal fluctuation within one ICD revision ("normal" fluctuation being defined as 2 standard deviations), the correspondences were re-examined and corrected if necessary by adding or suspending some links.

Table 11 Number of associations by type

Association type	Number of associations	Death counts by type of association (1979)	Proportions (%)
Simple correspondence (1:1)	178	292930	41,2
Splitting (N:1)	48	31961	4,5
Joining (1:N)	11	12682	1,8
Complex exchange (N:N)	67	373829	52,5
Total	304	711402	100

We constructed a total of 304 elementary associations. Table 11 shows the proportion of the associations by type. More than a half of the associations are simple correspondences (1:1). The second most frequent type is that of complex associations (N:N), followed by the splitting of

one ICD8 item into several ICD9 items (N:1). In terms of death counts, the majority (52.5%) of deaths included in the reconstruction were classified in the complex associations.

Transition coefficients

In simple associations (1:1) 100% of the old item corresponds to the new item. Also, if several ICD9 items join to form a single ICD8 item, then 100% of each ICD9 item joins to obtain the respective ICD8 item, which is a simple sum of all the ICD9 items in question. Conversely, if ICD9 is redistributed to the ICD8 structure, the ICD8 item is divided proportionally among the ICD9 items in 1979.

If one ICD9 item splits into several ICD8 items, the hypothetical distribution of deaths in 1978 according to ICD9 is obtained by applying the proportions of ICD8 items in 1978 to the death counts from the ICD9 item in 1979. Conversely, to obtain the ICD9 distribution in 1978 and backwards, we simply summarize 100% of each ICD8 item entering the association.

The following description refers to one of the 68 cases where we dealt with complex exchanges between the items. Using Association 138 as an example, we will demonstrate how to estimate the percentages of death count exchange between the respective items. To do so, we first construct a double classification cross-table (Table 12).

Table 12 Double classification cross-table to redistribute deaths in the transition years 1978 and 1979

Items of ICD9	Items of ICD8						Deaths in 1979
	402	4001	412	414	425	429	
402	9204	123	1366				10693
412			1120	2		179	1301
414			37218		255		37473
425					130	906	1036
429			16412			449	16861
1979 (estimate)	9204	123	56116	2	385	1534	67364
1978 (real)	9042	121	55126	2	378	1507	66176

In the beginning, we only have the death counts observed in 1978 classified under ICD8 and in 1979 classified under ICD9. We then calculate the hypothetical distribution of the deaths in 1979 according to the proportions observed in 1978. The core of the method is to redistribute the deaths inside the cross-table. As the shaded areas mean there is no correspondence between the two items, the non-shaded areas have to be filled. The entire content (100%) of ICD8 item 402 and ICD8 item 4001 are distributed to ICD9 item 402 and the entire content of ICD8 item 414 to ICD9 item 412. To obtain the portion of ICD8 item 412 that forms the rest of ICD9 item 402, we simply subtract the known death counts from the death counts observed in 1979 ($10,693 - 9,204 - 123 = 1,366$). In some associations, only one cross-classification is possible. The selected example represents a case in which several redistribution variants are possible, as we cannot directly estimate the cross-classification of ICD8 items 412, 425, and 429. Here, we decided to first redistribute the deaths from the ICD9 items 414 and 429 proportionally to the

hypothetical death counts of the corresponding ICD8 items estimated for 1979 and to fill the remainder of the table by subtraction.

The table of transition coefficients (Table 13) is then directly derived from the completed cross table (Table 12). At this point, we can choose to redistribute the content of the ICD8 items to ICD9 or vice versa. If one classification is considerably less detailed than the other (as in our case 480 ICD8 items versus 892 ICD9 items), it is useful to first reclassify the deaths according to the “shorter” classification, the rationale being to obtain the double-classification rather by totalizing than by dividing individual ICD items. Therefore, distinguishing neither age group nor sex, we first reclassified the deaths from the three post-transition years (1979-1981) into the terms of ICD8. Based on this “double coding”, we then calculated the coefficients of transition from ICD8 to ICD9 by age group and sex. These coefficients were then applied to calculate the time series between 1968 and 1978, under the assumption of time-constant cause-of-death distribution within the elementary associations.

Table 13 Transition coefficients between ICD9 and ICD8

Items of ICD9	Items of ICD8						Sum
	402	4001	412	414	425	429	
402	0.861	0.012	0.128				1.000
412			0.861	0.002		0.138	1.000
414			0.993		0.007		1.000
425					0.125	0.875	1.000
429			0.973			0.027	1.000

Keeping the coefficients constant may create systematic biases in the associations where the relative proportions of items change over time (as would be the case of association 153 after the year 1978).⁴⁵ We have no means to measure the magnitude of such bias, but we minimize it by working with sufficiently detailed data.

Results

The following figures show the items of selected elementary associations before and after applying the transition coefficients.

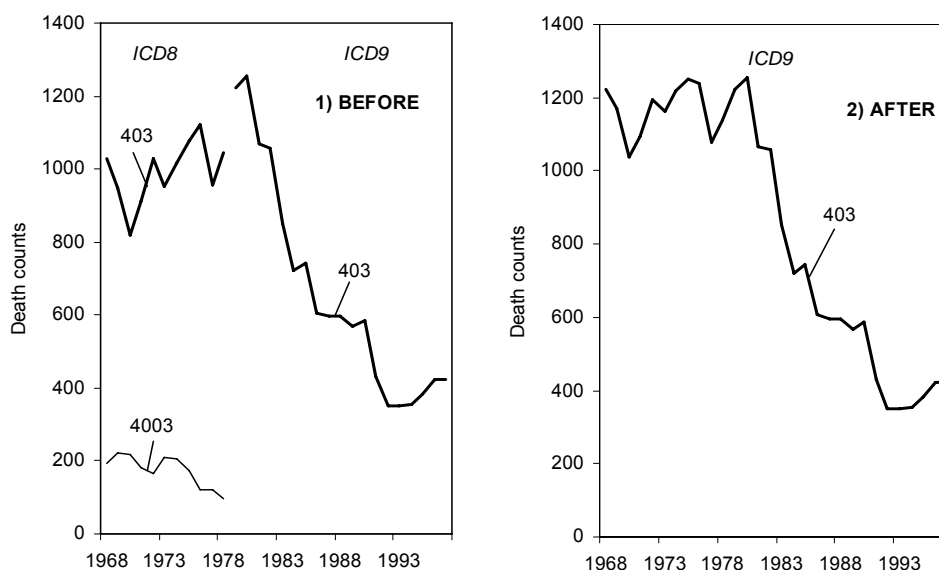
In Figure 13, the series for ICD9 item 403, *Hypertensive renal diseases*, is created by a simple sum of ICD8 items 403 and 4003, while most of the content comes from ICD8 item 403. Even though the curve is not perfectly smooth, the break at the time of the classification change does not exceed the fluctuations observed in ICD8.

Association 153 (Figure 14) deals with diseases of arteries, arterioles, and capillaries. The grouped ICD8 item 44a, *Remaining diseases of arteries, arterioles and capillaries*, splits to form several items under ICD9. The major part of ICD8 item 44a is attributed to ICD9 item 443, *Other peripheral vascular disease*, - a cause of death that has shown an exemplary decline

⁴⁵ It is noteworthy that such weakness is also common to the reconstruction method based on the comparability ratios available in countries where the bridge coding allows for it.

since the 1980s, while the death counts from the remaining causes of this association were stable over the entire period.

Figure 13 Example of the elementary association before and after the reconstruction. Association 139



ICD8 items (1968-1978)

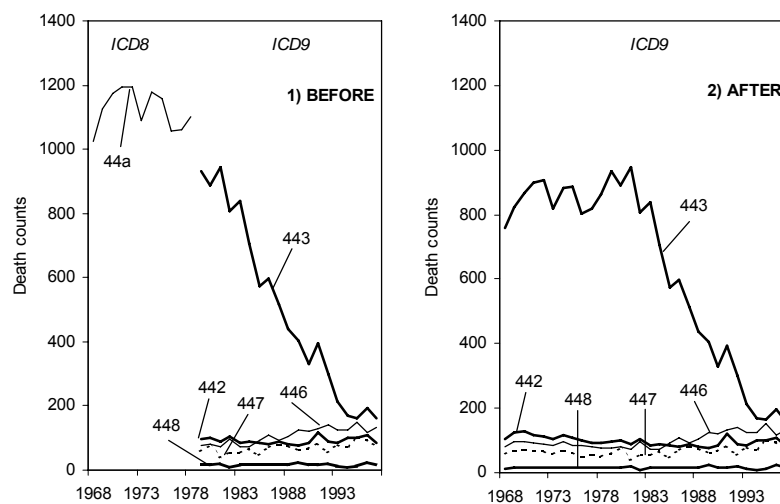
ICD9 items (1979-1997)

403 Hypertensive renal disease

403 Hypertensive renal disease

4003 Malignant hypertension with renal involvement

Figure 14 Example of the elementary association before and after the reconstruction. Association 153



ICD8 items (1968-1978)

ICD9 items (1979-1997)

44a Remaining diseases of arteries, arterioles, and capillaries

442 Other aneurysm

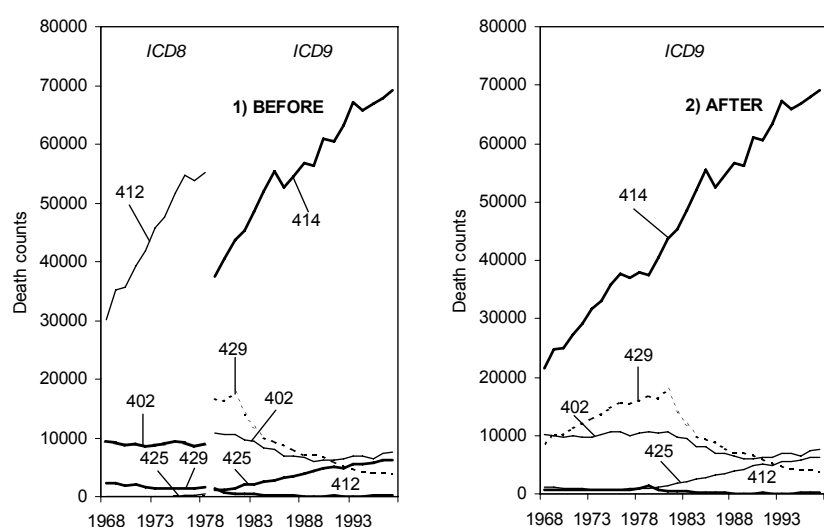
443 Other peripheral vascular disease

446 Polyarteritis nodosa and allied conditions

Other disorders of arteries and arterioles

447 Disease of capillaries

448

Figure 15 Example of the elementary association before and after the reconstruction. Association 138

ICD8 items (1968-1978)

402	Hypertensive heart disease
4001	Malignant hypertension with heart involvement
412	Chronic ischemic heart disease
414	Asymptomatic ischemic heart disease
425	Cardiomyopathy
429	Ill-defined heart disease

ICD9 items (1979-1997)

402	Hypertensive heart disease
412	Old myocardial infarction
414	Other forms of chronic ischemic heart disease
425	Cardiomyopathy
429	Ill-defined descriptions and complications of heart disease

Figure 15 represents a complex association. The main item here is ICD9 item 414, Other forms of ischemic heart disease, one of the most important single causes of death per se. ICD8 item 412, Chronic ischemic heart disease, provides the decisive share of deaths for ICD9 item 414. The remainder of the 55,126 deaths from ICD8 item 412 in 1978 was distributed primarily to ICD9 item 429, Ill-defined heart disease, and helped to level off the break between item 402 in ICD8 and ICD9.

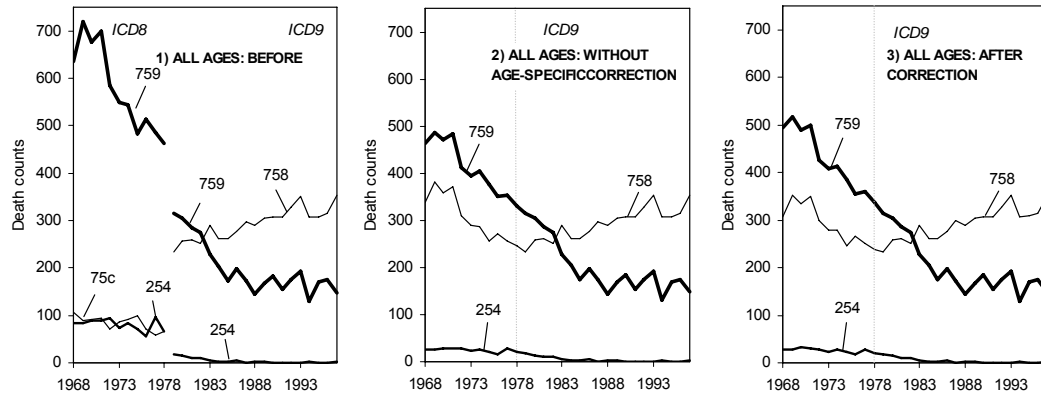
Age-specific treatment of time series

By default, we assume that exchanges take place with the same proportion across all age groups. In rare cases, however, specific age groups need to be treated separately. To identify and correct such breaks, the time series were examined by 5-year age groups.

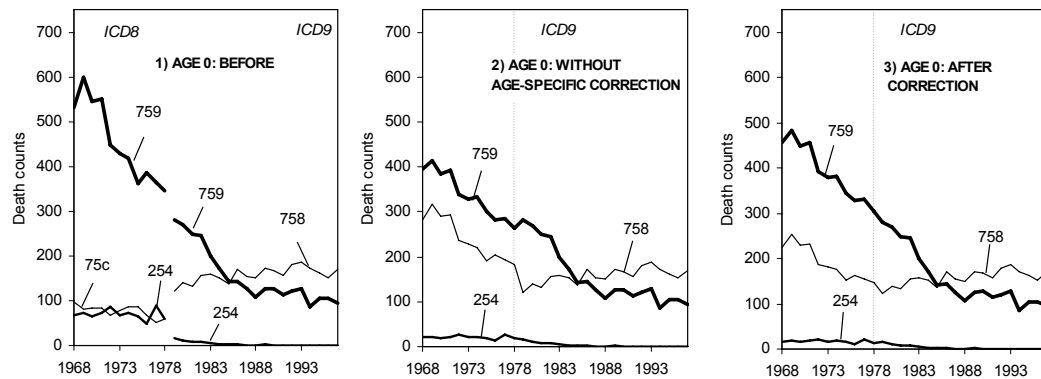
Figure 16 represents one of the cases, where different transitions apply for different age groups. According to the correspondence tables released by the Federal Statistical Office, there should be a 100% correspondence between the diseases of thymus gland in ICD8 and ICD9 (ICD8/ICD9 item 254). However, it is evident from first graph in row a) that in ICD8 many more deaths were classified under diseases of thymus gland than in ICD9. The age-specific inspection revealed that these excess deaths without continuation in ICD9 occurred only in infants (first graph in row b). For higher age groups the correspondence between the diseases of thymus gland in ICD8 and ICD9 was satisfying (first graph in row c). The continuation of the infant deaths from diseases of thymus gland under ICD8 was found in other and unspecified congenital anomalies of ICD9 (item 759).

Figure 16 Elementary association: before reconstruction (1), without age-specific correction (2) and after age-specific correction (3). Association 239"

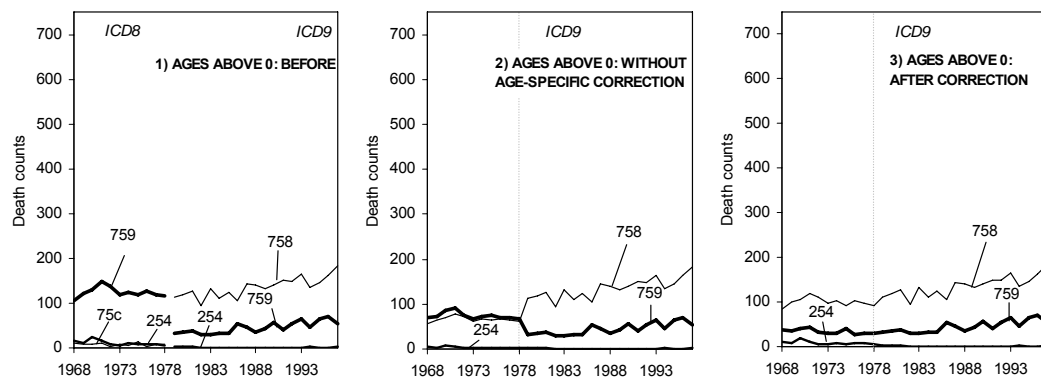
a) For all ages



b) For age 0



c) For ages above 0



ICD8 items (1968-1978)

254	Diseases of thymus gland
75c	Other and unspecified congenital anomalies
759	Congenital syndromes affecting multiple systems

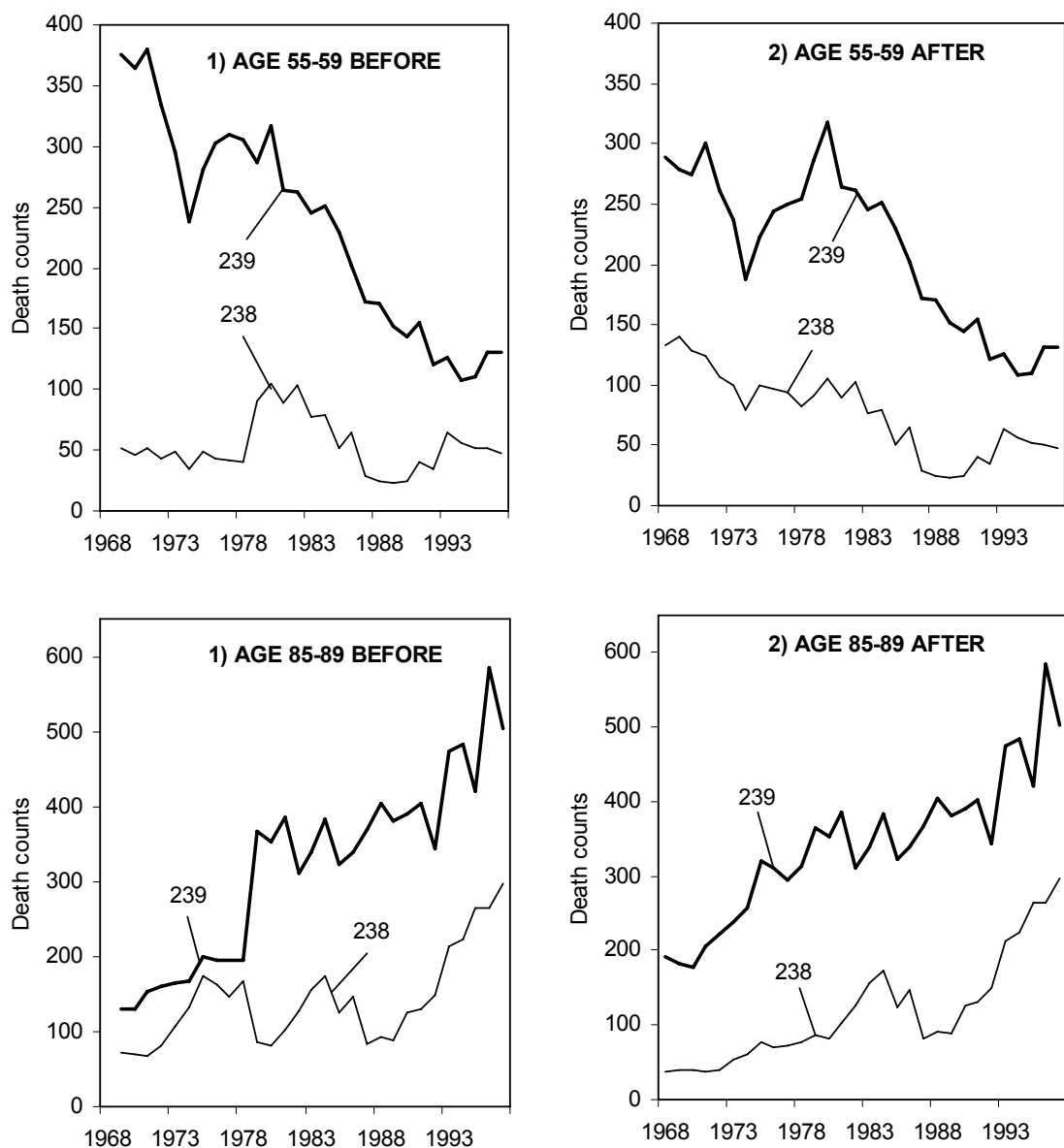
ICD9 items (1979-1997)

254	Diseases of thymus gland
758	Chromosomal anomalies
759	Other and unspecified congenital anomalies

The middle graphs in each row show what the situation would look like if, hypothetically, we applied the same transition coefficients for all age groups. Due to the imbalance between age groups, the transition coefficients distort the proportions of items 758 and 759 (see the middle graphs in row b) and c). To resolve this issue, we associate the excess infant deaths of ICD8

item 254 with ICD9 item 759, while for ages above 0, we leave the original correspondence. In the language of transition coefficients, ICD8 item 254 will form 100% of ICD9 item 254 plus 13.5% of ICD9 item 759 at age 0, while for higher age groups the entire content (100%) of ICD8 item 254 will be transformed into ICD9 item 254. This procedure ensures smooth trends across all age groups.

Figure 17 Results of the application of age-specific corrected transition coefficients.
Association n° 103



ICD9 238 Neoplasm of uncertain behaviour of other and unspecified sites and tissues
ICD9 239 Neoplasms of unspecified nature

Apart from the inconsistencies for the first year of life described above and addressed previously at the level of the elementary associations, other causes of death were found to be inconsistent by age. This was the case of items from Association n° 103 dealing with neoplasms without further specification of site or behaviour. While checking the series by age, it appeared

that for age groups 35-39 to 75-79 the original transition coefficients, estimated from the total of all age groups, attributed too many deaths to ICD9 item n° 238, *Neoplasm of uncertain behaviour of other and unspecified sites and tissues*, while these deaths were systematically missing in the ICD9 item n° 239, *Neoplasms of unspecified nature*. The situation reversed after age group 75-79. At age groups below 35-39, the death counts were too few to reflect this change in the coding practices.

The middle graphs in each row show what the situation would look like if, hypothetically, we applied the same transition coefficients for all age groups. Due to the imbalance between age groups, the transition coefficients distort the proportions of items 758 and 759 (see the middle graphs in row b) and c). To resolve this issue, we associate the excess infant deaths of ICD8 item 254 with ICD9 item 759, while for ages above 0, we leave the original correspondence. In the language of transition coefficients, ICD8 item 254 will form 100% of ICD9 item 254 plus 13.5% of ICD9 item 759 at age 0, while for higher age groups the entire content (100%) of ICD8 item 254 will be transformed into ICD9 item 254. This procedure ensures smooth trends across all age groups.

The association contained several complex exchanges, which led us to the estimation of transition coefficients from the cross tables for all age groups above 35-39 individually. Both situations (i.e. before and after age 75-79), both before and after the age specific correction of transition coefficients are represented at Figure 17. This was a rare case, similar adjustments by age were made only in three other items.⁴⁶

Beyond the classification changes

The discontinuities introduced by the classification change are not the only difficulties involved in the study of cause-of-death patterns. Within one ICD revision, sudden or gradual changes in coding practices can appear. The sudden changes can be identified and corrected by exchanging a portion of deaths between the items in question during the last stage of the time-series reconstruction. The gradual changes, on the other hand, are neither easily identifiable nor correctable within the scope of the applied method.

Unique case of the emergence of AIDS

AIDS is the first example selected to demonstrate how the series were treated during the final corrections. The first deaths from AIDS emerged worldwide in the early 1980s and in the next few years the infection became a serious health threat. There was no category for AIDS in the original version of ICD9, but as the need of AIDS mortality surveillance was acute, WHO accepted - for the first time in the history of ICD - to modify the current classification before the release of the new revision. It did so in 1986 when releasing an addendum to the 9th revision (WHO 1986). Three new 3-digit items were assigned to distinguish different forms of AIDS, namely item 042, *Human immunodeficiency virus [HIV] disease*, item 043, *AIDS-related complex (ARC)*, and item 044, *Other HIV infection*. However, not all countries adopted this addendum when it was published. In West Germany, the new items entered the tabulation from 1989, following the recommendations of the Centres for Disease Control (CDC 1987).

⁴⁶ For details, see ANNEX\ 2 - TRANSITION BETWEEN ICD8 AND ICD9\Transition coefficients

Prior to the addendum, deaths involving HIV infection were usually classified under ICD9 item 279.1, *Deficiency of cell-mediated immunity*, but also under malignant neoplasms, including neoplasms of lymphatic and haematopoietic tissues, and possibly under a number of other causes.

Figure 18 Death counts from AIDS by 5-year age groups, both sexes, 1968-1997

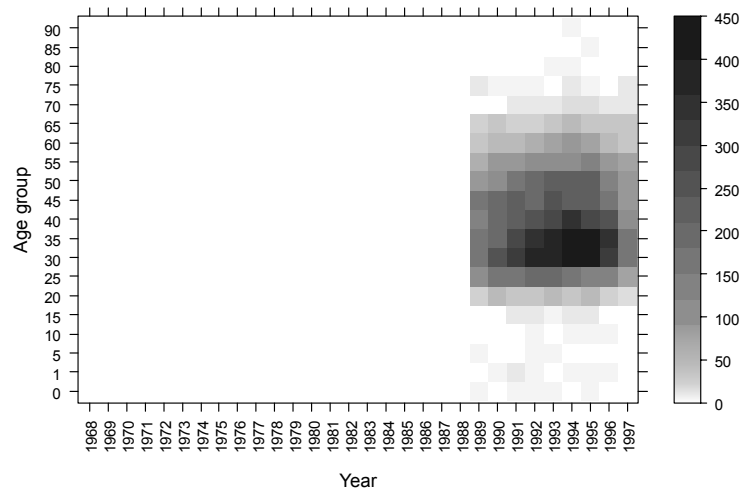


Figure 19 Death counts from Other and unspecified infectious and parasitic diseases by 5-year age groups, both sexes, 1968-1997

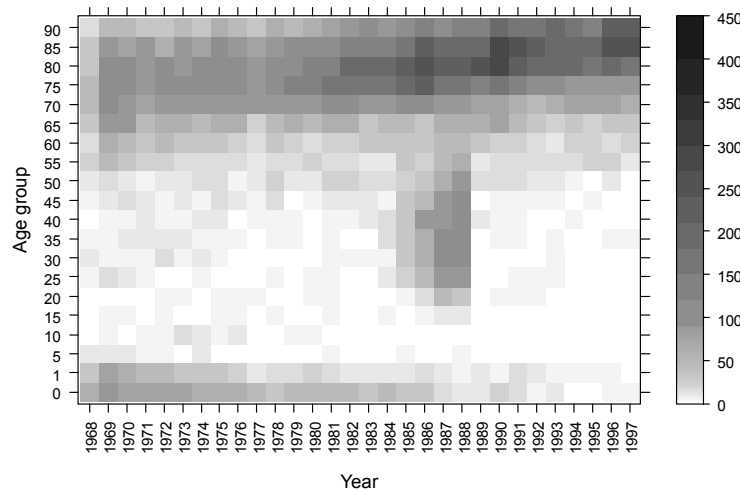
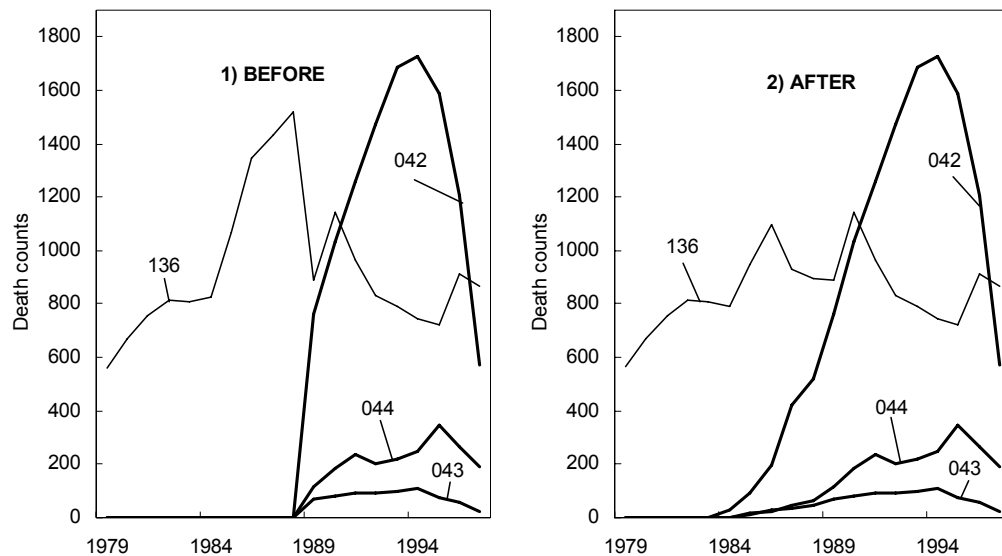


Figure 18 and show how we identified the deaths from AIDS in West Germany using age-specific visual inspection. While the ICD9 item 279 showed virtually no increase in death counts (not shown here), the gradual emergence of middle-age deaths in ICD9 item 136 *Other and unspecified infectious and parasitic diseases* between 1984 and 1988 matches exactly the age structure of AIDS mortality. Unlike for other countries, West Germany thus classified AIDS, from the beginning, in the chapter of infectious diseases.

We extrapolated the AIDS series backwards by redistributing the excess deaths from ICD9 item 136 by 5-year age groups. The resulting pattern provides a more accurate image of

the actual AIDS mortality in West Germany, as well as the corrected trend for ICD9 item 136 *Other and unspecified infectious and parasitic diseases* (Figure 20).⁴⁷

Figure 20 Number of deaths related to HIV infection before and after ex-post correction



ICD9 items:
 042 Human immunodeficiency virus [HIV] disease
 043 AIDS-related complex (ARC)
 044 Other HIV infection
 136 Other infectious and parasitic diseases

Sudden changes in coding practices

Apart from AIDS-related exchanges, another 16 ICD9 items were corrected. We will focus on some exchanges in more detail.

In West Germany, many breaks subject to such ex-post corrections occurred in the years close to the classification change, suggesting that there were initial discordances related to the adoption of the new revision and its coding rules.

⁴⁷ Most of the excess content of the ICD9 item n° 136 was assigned to item n° 042. The corrections were limited to age 15-64, but the maximum toll of transferred deaths was in age group 25-49 and the transfers increased with time. Thus, in 1988 more than 98% of the content of ICD9 item n° 136 in age group 30-39 was moved to the AIDS-related ICD9 items n° 042-044.

Figure 21 Number of deaths from ICD9 item 485 Bronchopneumonia, organism unspecified and ICD9 item 486 Pneumonia, organism unspecified, before and after the ex-post correction

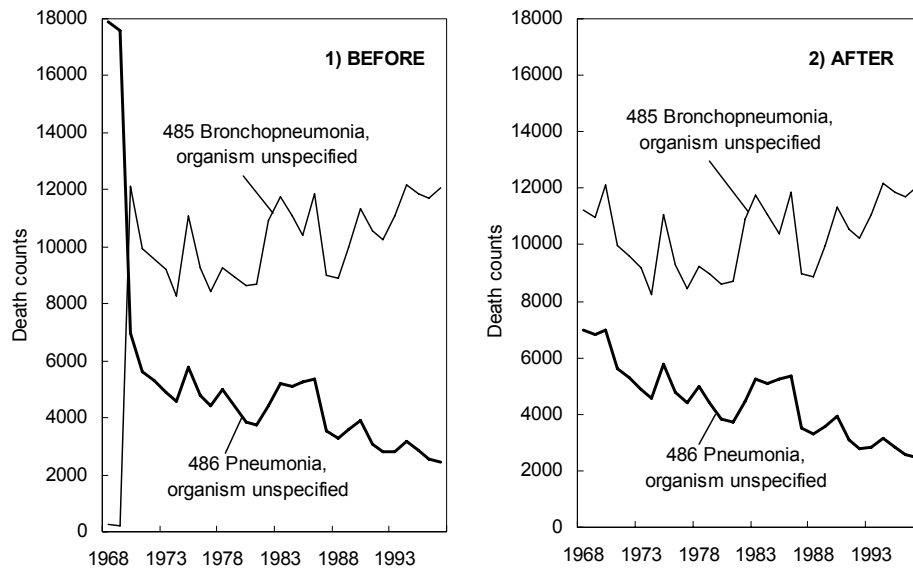


Figure 22 Number of deaths from ICD9 item 427 Cardiac dysrhythmias and ICD9 item 421 Old myocardial infarction, before and after the ex-post correction

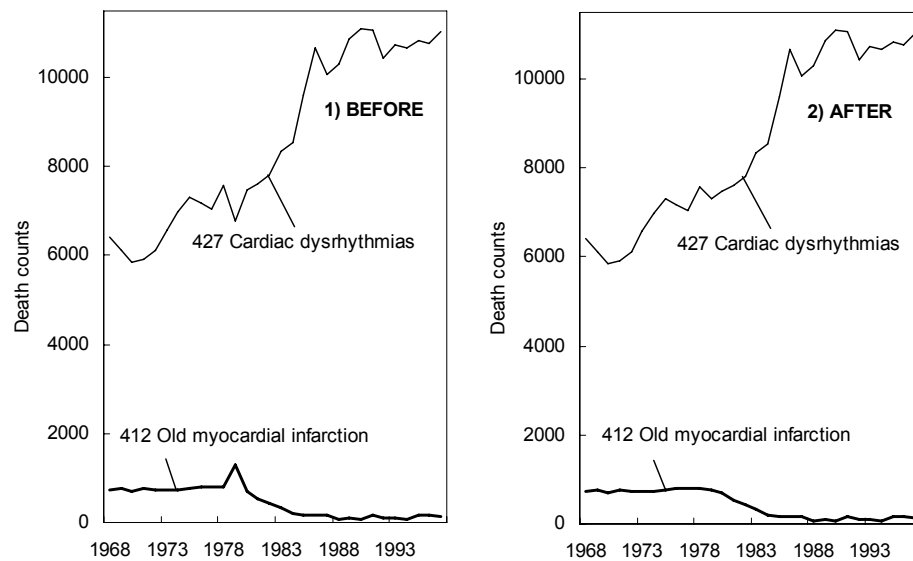


Figure 21 shows a situation related to the adoption of the 8th ICD revision in 1968. For the first two years of ICD8, the reconstructed ICD9 item 486, *Pneumonia, organism unspecified*, contained no deaths. In 1970, the death counts suddenly rose from 0 to 11,987, while the number of deaths classified under ICD9 item 485, *Broncho-pneumonia, organism unspecified*, dropped from 17,591 in 1969 to 6,957 in 1970, perfectly coinciding with an increase in pneumonia of unspecified etiological agents. We corrected this break by exchanging the deaths between these categories across all age groups.

A similar kind of exchange, but for the first year of ICD9, was required for ICD9 item 427, *Cardiac dysrhythmias* and ICD9 item 421, *Old myocardial infarction*, transferring the deaths for age 35 and above (Figure 22). In this case, the correction was made only to the first year of ICD9.

Another example (Figure 23) solves the problem of Association n° 80 - the excess of deaths in item n° 192 against the depression of the death counts in the item n° 191 in 1979, and a sudden decrease in death counts from ICD9 item n° 191, *Malignant neoplasm of brain*, in 1972. In 1979, the problem was identified in age groups 25-79 and 20%-50% (according to age) of the deaths were transferred from item n° 192 to item n° 191. In 1972, the corresponding excessive deaths in age groups 50-54 to 70-74, where the deaths were missing in the item n° 191, were only found in the group of ill-defined cancers, i.e. the reconstructed ICD9 item n° 239 *Neoplasms of unspecified nature*.

Figure 23 Number of deaths from ICD9 item n° 191 *Malignant neoplasm of brain* and ICD9 item n° 192 *Malignant neoplasm of other and unspecified parts of the nervous system*, before and after the correction a posteriori

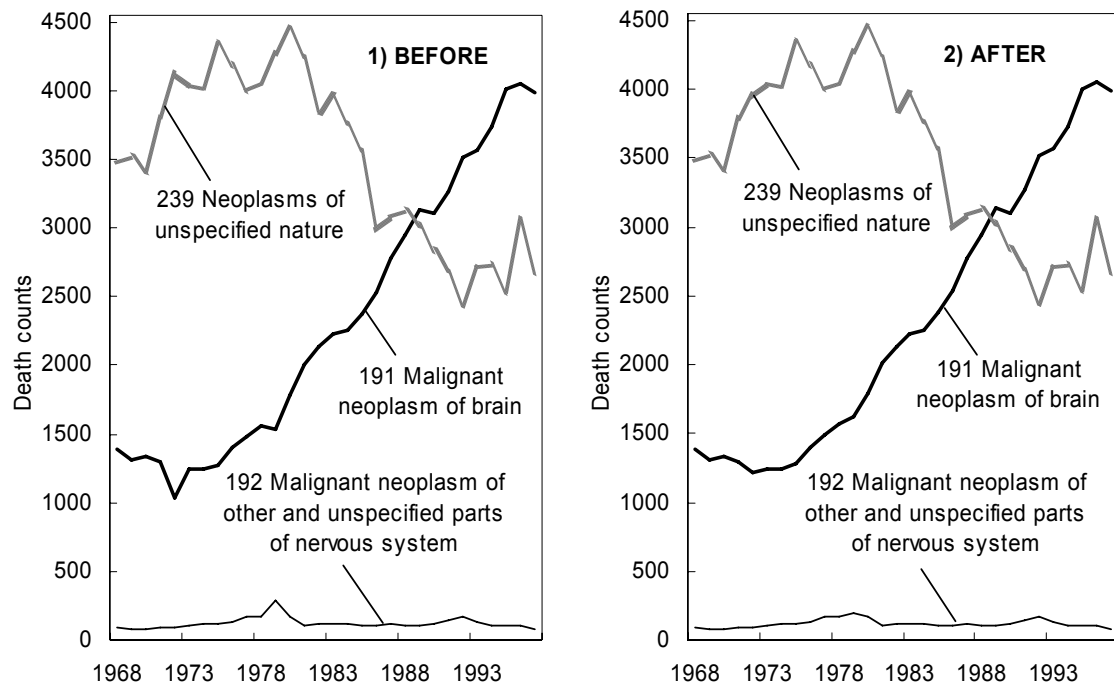


Table 14 Percentages of exchange between ICD9 items in 1968-1997

Deaths transferred from ICD item	To ICD item	Age group	Proportions (%)																
			1968	1969	1970-1971	1972	1973-1975	1976	1977	1978	1979	1980-1983	1984	1985	1986	1987	1988	1989-1997	
136	042	15-19											0.0	33.3	25.0	44.4	50.0		
		20-24											0.0	0.0	46.2	69.7	67.9		
		25-29											62.5	66.7	67.7	84.1	82.8		
		30-34											33.3	63.6	77.6	84.2	81.5		
		35-39											75.0	47.8	72.0	78.4	81.4		
		40-44											66.7	73.3	81.9	81.1	78.3		
		45-49											20.0	45.8	60.0	73.0	83.8		
		50-54											23.1	23.5	34.6	54.3	62.3		
		55-59											0.0	53.6	42.1	55.0	50.0		
136	043	60-64											0.0	0.0	0.0	37.5	41.2		
		15-19											0.0	25.0	11.1	12.5			
		20-24											0.0	7.7	6.1	7.1			
		25-29											5.6	9.7	5.8	5.7			
		30-34											9.1	6.1	5.3	7.4			
		35-39											26.1	20.0	10.3	8.8			
		40-44											6.7	4.2	4.4	5.4			
		45-49											4.2	5.7	4.8	5.4			
		50-54											5.9	7.7	6.5	7.2			
136	044	55-59											3.6	5.3	5.0	11.4			
		20-24											0.0	0.0	7.7	9.1		10.7	
		25-29											0.0	11.1	9.7	7.2		8.0	
		30-34											0.0	9.1	6.1	6.3		9.3	
		35-39											0.0	13.0	4.0	7.2		8.0	
		40-44											0.0	6.7	5.6	6.7		8.7	
		45-49											0.0	20.8	17.1	12.7		8.1	
		50-54											0.0	11.8	11.5	15.2		14.5	
		55-59											10.0	10.7	15.8	12.5		13.6	
192	191	25-29											22.2						
		30-34											41.7						
		35-39											50.0						
		40-44											53.3						
		45-49											30.8						
		50-54											31.8						
		55-59											50.0						
		60-64											47.2						
		65-69											44.7						
		70-74											26.7						
230	239	75-79											20.0						
		35-39											100.00						
		45-49											100.00						
		55-59											100.00						
		60-64											81.82						
		65-69											86.21						
		70-74											81.25						
		75-79											83.67						
		80-84											83.33						
		85-89											77.78						
231	239	90+											100.00						
		55-59											100.00						
		60-64											100.00						
		65-69											33.33						
		70-74											81.25						
232	239	75-79											88.24						
		70-74											100.00						
		75-79											76.47						
		80-84											73.91						
		85-89											100.00						
233	239	90+											100.00						
		70-74											66.67						
		80-84											70.00						
234	239	85-89											100.00						
		90+											100.00						
239	191	50-54											66.67						
		55-59																	
		60-64																	
		65-69																	
		70-74																	
412	427	75-79											15.0						
		80-84											19.6						
		85-89											11.5						
		90+											6.8						
		35-39											3.0						
		40-44																	
		45-49																	
		50-54																	
		55-59																	
		60-64																	
485	486	65-69																	
		70-74																	
		75-79																	
		80-84																	
		85-89																	
		90+																	
		0																	
		1-4																	
		Other																	
		E876	E928	30-34															
35-39											84.5								
40-44											80.2								
45-49											60.0								
50-54																			
55-59																			
60-64																			
65-69																			
70-74																			
E928	E919	75-79																	
		80-84																	
		85-89																	
		90+																	
		65-69																	
		70-74																	
E928	E929	75-79																	
		80-84																	
		85-89																	
		90+																	
		65-69																	
		70-74																	

4.2.2 Czech Republic

The double coding for ICD8/ICD9 was not available for Czech Republic either. Different structure of the ICD8 data (grouped items in West Germany versus full 3-digit ICD8 detail in Czech Republic) did not allow to even test the German coefficients on the Czech data.

By the same logic, the correspondence tables for West Germany were of limited application to the Czech Republic. Where needed, the correspondences were therefore derived directly from the ICD8 and ICD9 manuals and indexes. In problematic cases we referred to the associations between ICD8 and ICD9 constructed on the French data by Meslé and Vallin (a document not published).⁴⁸

Elementary associations

The result of combining these various sources of information was a total of 601 associations, i.e. roughly a double compared to West Germany. In almost 78% of cases these were the simple (1:1) correspondences. There was a minimum of splitting and joining, but surprisingly the number of complex associations virtually equalled the number observed previously in West Germany (69 versus 67).

Another similarity was in the structure of associations by death counts: in both countries the simple associations contained around 40% of deaths, while the majority of death was clustered in complex associations – 44% in Czech Republic, 52% in West Germany.

Table 15 *Number of associations by type*

Association type	Number of associations	Death counts by type of association (1979)	Proportions (%)
Simple correspondence (1:1)	473	54607	42,7
Splitting (N:1)	33	11220	8,8
Joining (1:N)	26	5250	4,1
Complex exchange (N:N)	69	56872	44,4
Total	601	127949	100

Due to inter-country differences in the coding practices we ended up with associations that in many cases differed from the West German version. To provide an insight into the comparability of the transition between two countries, we selected a few examples of associations which deal with the same diseases as associations presented for the West Germany.

The selected simple associations – Acute myocardial infarction (410) and Angina pectoris (413) were identical in Czech Republic and in West Germany (Table 16).

⁴⁸ The associations were constructed on the 4-digit level.

Table 16 Examples of elementary associations: Czech Republic

ICD9				ICD8		
Code	Title	Deaths in		Code	Portion	Title
		1979	1978			
410	Acute myocardial infarction	15589	14657	410	T	Acute myocardial infarction
	Sum	15589	14657			

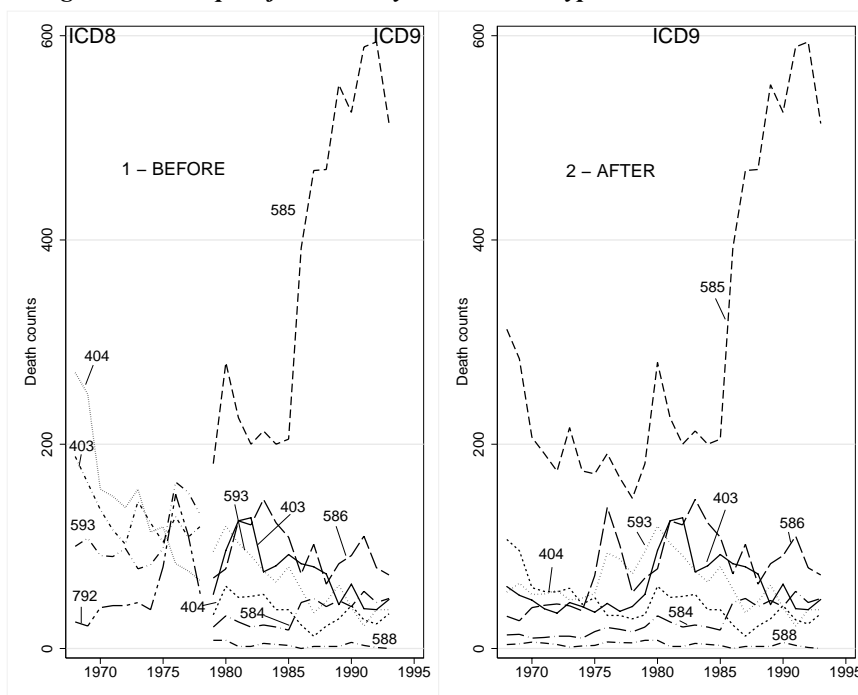
ICD9				ICD8		
Code	Title	Deaths in		Code	Portion	Title
		1979	1978			
413	Angina pectoris	37	22	413	T	Angina pectoris
	Sum	37	22			

For the next presented ICD9 item - Hypertensive renal disease - the correspondence seen in West Germany (Table 10 Association 139) could not be applied for two reasons: 1) the Czech data do not allow to split ICD8 item 400 into 4-digit detail, and 2) the death counts from ICD8 403 (Hypertensive renal disease) in 1978 were too abundant. Moreover, it is the character of the renal hypertension itself which makes the association difficult: hypertensive renal disease is a complex condition whose advanced stages produce renal failure, classified under ICD9 items 585, 586 and 587.

The instructions in the ICD9 manual (WHO and Avicenum 1978) say to classify renal failure (ICD9 585-587) as hypertensive renal disease (ICD9 403) if mentions of essential hypertension (ICD9 401) are present. This makes the ICD9 conditions 403 and 585-587 sensitive both to completeness of information on the death certificate (presence of hypertension or not) and to the coding practices. In the context of the Czech data, the excessive of ICD8 deaths from renal hypertension were compensated by associating with ICD9 chronic renal failure (585). Chronic renal failure brought further items which resulted in a complex association as seen in Table 17 and Figure 24.

Table 17 Example of elementary association: hypertensive renal disease

ICD9				ICD8		
Code	Title	Deaths in		Code	Portion	Title
		1979	1978			
403	Hypertensive renal disease (neglected)	53	120	403 (400)	P P	Hypertensive renal disease
585	Chronic renal failure	181	66	403 404 593 792	P P P P	Hypertensive heart and renal disease Other diseases of kidney and ureter Uremia
404	Hypertensive heart and renal disease (neglected)	33		404 (400)	P P	
584	Acute renal failure	21		593	P	
586	Renal failure, unspecified (neglected) (neglected)	69		593 (404) 792 (403)	P P P P	
588	Disorders resulting from impaired renal function	8		593	P	
593	Other disorders of kidney and ureter	95		593	P	
	Sum	460	367			

Figure 24 Example of elementary association: hypertensive renal disease

ICD8 items (1968-1978)		ICD9 items (1979-1993)	
403	Hypertensive renal disease	403	Hypertensive renal disease
404	Hypertensive heart and renal disease	404	Hypertensive heart and renal disease
593	Other diseases of kidney and ureter	584	Acute renal failure
792	Uremia	585	Chronic renal failure
		586	Renal failure, unspecified
		588	Disorders resulting from impaired renal function
		593	Other disorders of kidney and ureter

Another example presented for West Germany dealt with vascular diseases. The correspondences for these diseases, as observed in Czech Republic, are virtually the same (Table 18). They only benefit from the full detail of ICD8 and add more correspondences, such as ICD9 item 441 and ICD9 item 707.

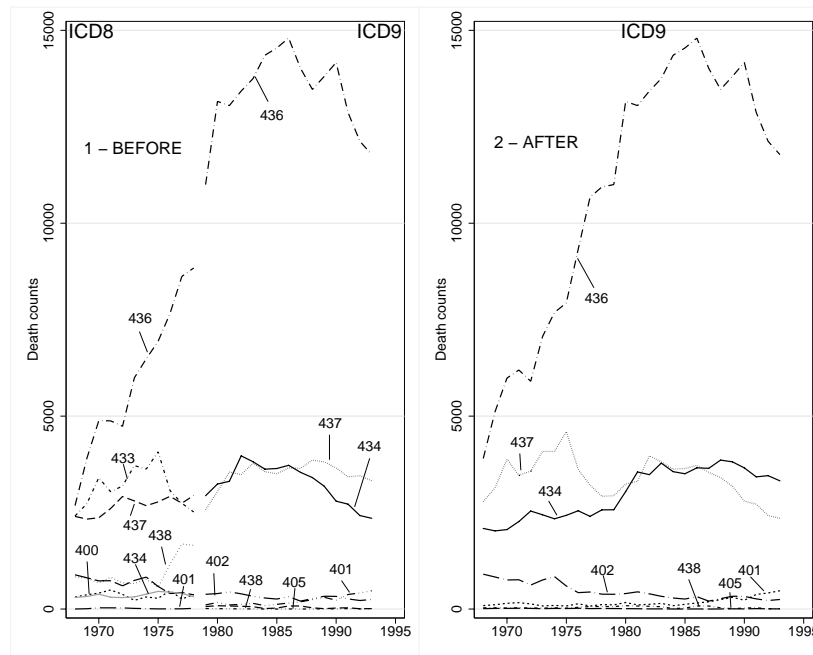
In the next example, once more, the absence of the 4th digit in the Czech data did not enable to split the malignant hypertension of ICD8 directly into its respective correspondents. The excessive deaths from malignant hypertension of ICD8 were therefore associated with acute but ill-defined cerebrovascular disease of ICD9 (item 436). The resulting association is presented in Table 19 and Figure 25.

Table 18 Examples of elementary associations: vascular diseases

ICD9				ICD8		
Code	Title	Deaths in		Code	Portion	Title
		1979	1978			
441	Aortic aneurysm and dissection	250	216	441	T	Aortic aneurysm (nonsyphilitic)
			55	442	P	Other aneurysm
442	Other aneurysm	39		442	P	
	Sum	289	271			
ICD9				ICD8		
Code	Title	Deaths in		Code	Portion	Title
		1979	1978			
443	Other peripheral vascular disease	57	44	443	P	Other peripheral vascular disease
	Sum	57	44			
ICD9				ICD8		
Code	Title	Deaths in		Code	Portion	Title
		1979	1978			
446	Polyarteritis nodosa and allied conditions	1	7	446	T	Polyarteritis nodosa and allied conditions
	Sum	1	7			
ICD9				ICD8		
Code	Title	Deaths in		Code	Portion	Title
		1979	1978			
447	Other disorders of arteries and arterioles	6	2	447	P	Other disease of arteries and arterioles
	(neglected)		33	707	P	Chronic ulcer of skin
	(neglected)			(440)	P	
				(445)	P	
707	Chronic ulcer of skin	21		707	P	
	Sum	27	35			
ICD9				ICD8		
Code	Title	Deaths in		Code	Portion	Title
		1979	1978			
448	Disease of capillaries	1	1	448	T	Disease of capillaries
	Sum	1	1			

Table 19 Example of elementary association: hypertension

ICD9				ICD8		
Code	Title	Deaths in		Code	Portion	Title
		1979	1978			
401	Essential hypertension	108	375	400	P	Malignant hypertension
			18	401	T	Essential benign hypertension
402	Hypertensive heart disease	382		400	P	
			367	402	T	Hypertensive heart disease
405	Secondary hypertension	13		400	P	
	(neglected)			(404)	P	
436	Acute, but ill-defined, cerebrovascular disease	11002		400	P	
			8840	436	T	Acute but ill-defined cerebrovascular disease
			2946	437	P	Generalized ischemic cerebrovascular disease
			1651	438	P	Other and ill-defined cerebrovascular disease
437	Other and ill-defined cerebrovascular disease	2573		437	P	
438	Late effects of cerebrovascular disease	65		438	P	
(403)	(neglected)			(400)	P	
(404)	(neglected)			(400)	P	
(431)	(neglected)			(400)	P	
(432)	(neglected)			(400)	P	
	Sum	14143	14197			

Figure 25 Example of elementary association: hypertension

ICD8 items (1968-1978)		ICD9 items (1979-1993)	
401	Essential benign hypertension	401	Essential hypertension
402	Hypertensive heart disease	402	Hypertensive heart disease
433	Cerebral thrombosis	405	Secondary hypertension
434	Cerebral embolism	434	Occlusion of cerebral arteries
436	Acute but ill-defined cerebrovascular disease	436	Acute, but ill-defined, cerebrovascular disease
437	Generalized ischemic cerebrovascular disease	437	Other and ill-defined cerebrovascular disease
438	Other and ill-defined cerebrovascular disease	438	Late effects of cerebrovascular disease

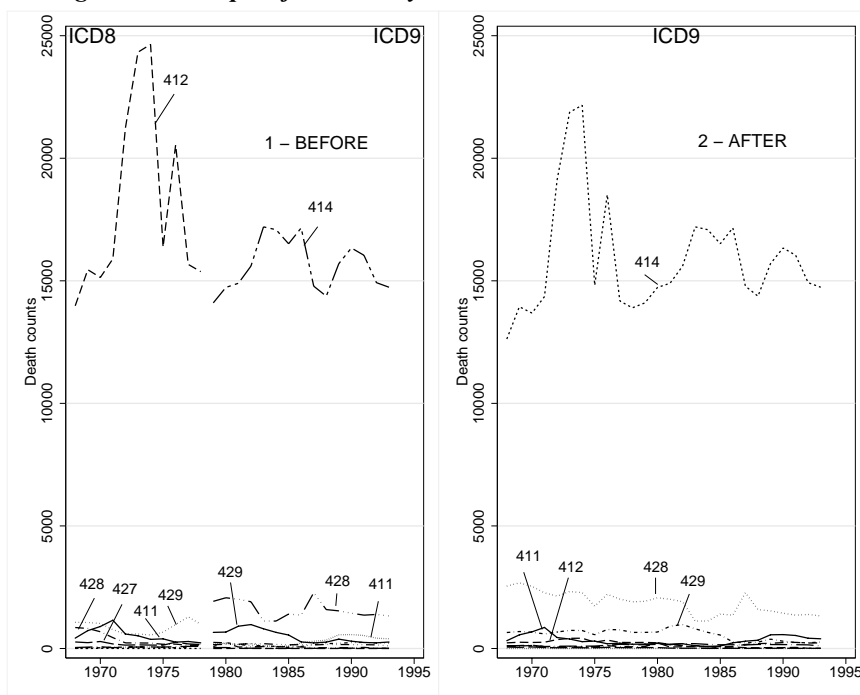
The remaining diseases of the West German association 138 belong into another complex association, which can be seen in Table 20 and Figure 26. Due to addition of ICD9's Heart failure, the analogous Czech association contains more items.

Table 20 Example of elementary association: cardiovascular diseases

ICD9				ICD8		
Code	Title	Deaths in		Code	Portion	Title
		1979	1978			
411	Other acute and subacute forms of ischemic heart disease	180	231	411	P	Other acute subacute forms of ischemic heart
428	Heart failure	1924	15375 111 988 163 175	411 412 428 429 427 782	P P T P P P	Chronic ischemic heart disease Other myocardial insufficiency Ill-defined heart disease Symptomatic heart disease Symptoms referable to cardiovascular and lymphatic system
412	Old myocardial infarction	248		412	P	
414	Other forms of chronic ischemic heart disease	14101	2	412 414	P T	Asymptomatic ischemic heart disease
429	Ill-defined descriptions and complications of heart disease	658		412	P	
425	Cardiomyopathy	154	87	429 425	P T	Cardiomyopathy
426	Conduction disorders	38		427	P	
427	Cardiac dysrhythmias	79		427	P	
785	Symptoms involving cardiovascular system	1		427 782	P P	
(799)	(neglected)			(427)	P	
(780)	(neglected)			(782)	P	
(789)	(neglected)			(782)	P	
	Sum	17383	17132			

Heart failure is a condition which may occur as a consequence of coronary heart disease, hypertension⁴⁹, valvular disease, cardiomyopathy, or several other diseases (Soufer 1992). Heart failure was also a subject of redefinition in ICD9. In ICD8 the heart failure as a 3-digit entity did not exist. Instead, the right (congestive) and left ventricular failure was part of ICD8 3-digit item *Symptomatic heart disease*, while unspecified heart failure was under ICD8 428 Other myocardial insufficiency. The acute unspecified heart failure was placed in the chapter of ill-defined diseases (ICD8 782.4). In the case of Czech Republic, these correspondences were not enough, the ICD9 heart failure was therefore associated with chronic ischemic heart disease of ICD8 (item 412).

⁴⁹ Hypertension is the second most frequent cause of heart failure (cit). ICD9 also states to code as 402 if heart failure is due to hypertension.

Figure 26 Example of elementary association: cardiovascular diseases

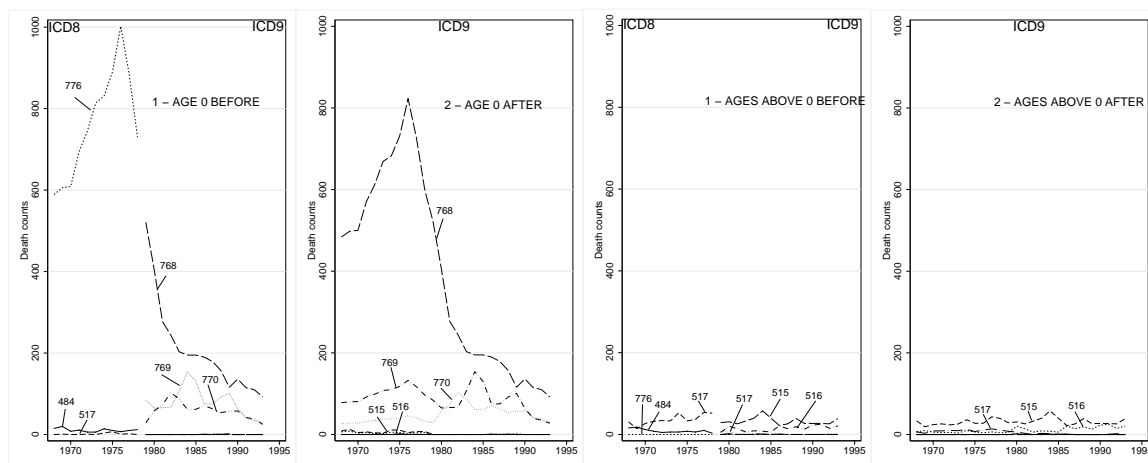
ICD8 items (1968-1978)

ICD9 items (1979-1993)

411	Other acute subacute forms of ischemic heart	411	Other acute and subacute forms of ischemic heart disease
412	Chronic ischemic heart disease	412	Old myocardial infarction
414	Asymptomatic ischemic heart disease	414	Other forms of chronic ischemic heart disease
425	Cardiomyopathy	425	Cardiomyopathy
427	Symptomatic heart disease	426	Conduction disorders
428	Other myocardial insufficiency	427	Cardiac dysrhythmias
429	Ill-defined heart disease	428	Heart failure
782	Symptoms referable to cardiovascular and lymphatic system	429	Ill-defined descriptions and complications of heart disease
		785	Symptoms involving cardiovascular system

The majority of associations constructed for the Czech Republic were not age-specific. The exception was the ICD8 item 484 Acute interstitial pneumonia, which was associated with ICD9 515 Postinflammatory pulmonary fibrosis and ICD9 516 Other alveolar and parietoalveolar pneumonopathy. Under ICD9 however, these two items did not contain virtually any infant deaths. The infant deaths from acute interstitial pneumonia were therefore associated with ICD9 769 Respiratory distress syndrome (Figure 27).⁵⁰

⁵⁰ It is also possible that some of these ICD8 infant deaths would correspond to the sudden infant death syndrome (SIDS) in ICD9, but the data do not give sufficient detail to support for this speculation. Moreover, we prefer to associate these deaths with a well defined, rather than a poorly defined cause such as SIDS.

Figure 27 Age-specific treatment of the association

ICD8 items (1968-1978)		ICD9 items (1979-1993)	
484	Acute interstitial pneumonia	507	Pneumonitis due to solids and liquids
517	Other chronic interstitial pneumonia	515	Postinflammatory pulmonary fibrosis
776	Anoxic and hypoxic conditions not elsewhere classifiable	516	Other alveolar and parietoalveolar pneumonopathy
		517	Lung involvement in conditions classified elsewhere
		768	Intrauterine hypoxia and birth asphyxia
		769	Respiratory distress syndrome

Corrections a posteriori

After the application of transition coefficients and verification of the data continuity it became apparent that the Czech data will need further treatment. A total of 39 reconstructed ICD9 items were corrected. Several causes of death bear evidence of a change in the coding which took place shortly after the adoption of ICD9. Other changes came in 1986.

Changes occurred during the ICD9 in the Czech Republic can be summarized in a following list:

- Between 1981-1985 a part of malignant neoplasms were coded as neoplasms of unspecified nature (235-237)
- Between 1981-1985 the exchange between lymphoid leukaemia (204) and leukaemia of specified (207) and unspecified cell type (208) was observed
- Since 1981 much fewer deaths were assigned to old myocardial infarction (412)
- Since 1982 the carcinoma in situ⁵¹ (230-234) does not appear in the Czech statistics
- Until 1985 the Czech data contained three “asterisk” items – secondary malignant neoplasm (196-198), not intended for use in mortality coding.

The motives of the Czech Statistical Office to change the coding practices are not known, as well as - in spite of repeated queries to the Czech Statistical Office- we could not find any official nor unofficial document with the respective directives. Our solutions are thus driven mainly by the observation of the series. Some of these cases are shown in the following figures, all the corrections are then summarized in Table 21.

⁵¹ Carcinoma in situ is a localized lesion with no potential for metastasis. It is considered as pre-cancer stage.

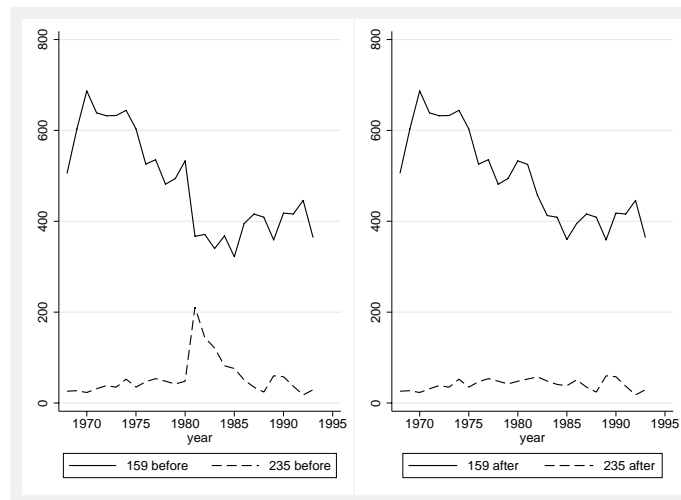
Table 21 Corrections a posteriori - Czech Republic

Deaths transferred from ICD item:	To ICD item	Proportions (%)													
		1968-1971	1972	1973-1974	1975	1976	1977-1978	1979	1980	1981	1982	1983	1984	1985	
196	200	100	100	100	100	100	100	100	100	100	100	100	100	100	
197	162	100	100	100	100	100	100	100	100	100	100	100	100	100	
198	191	100	100	100	100	100	100	100	100	100	100	100	100	100	
208	204										40	40	40	40	40
208	207										10	10	10	10	10
230	238	50	50	50	50	50	50	50	50	0					
230	239	50	50	50	50	50	50	50	50	100					
231	238	100	100	100	100	100	100	100	100	100					
232	238	100	100	100	100	100	100	100	100	100					
233	238	100	100	100	100	100	100	100	100	100					
234	238	100	100	100	100	100	100	100	100	100					
235	159										75	60	60	50	50
236	189										75	70	50	10	10
237	191										40	40	40	40	40
237	194										15	15	15	15	15
322	320	50	50	50	50	50	50	50	50						
412	410		10	13		10									
412	414	70	70	70	70	70	70	70	70						
414	410		28	34.1		21.6									
424	396										50	50	50	50	50
444	557								30						
491	496								5						
562	578	60	60	60	60	60	60	60							
585	403	40	40	40	40	40	40	40	40						
913*	798*	62	62	62	62	62	62	62							

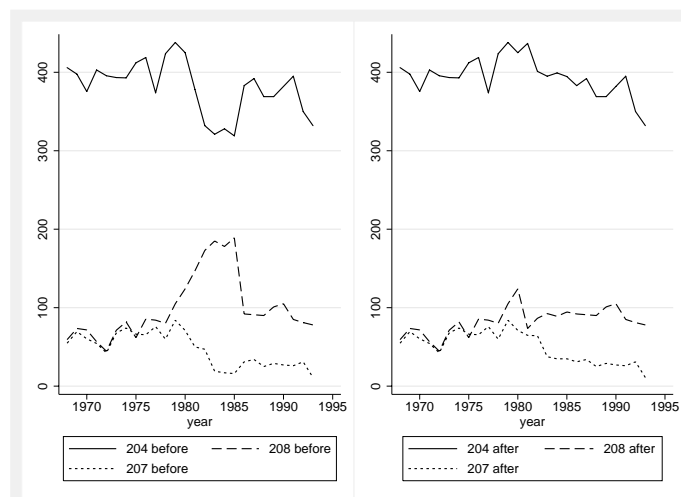
* correction limited to age 0, the exchange will be discussed later in the chapter dealing with ill-defined causes of death.

Figure 28 shows the correction of the temporary tendency to code some neoplasms as of unspecified nature. The change concerned three ICD9 items: ICD9 235 Neoplasm of uncertain behaviour of digestive and respiratory systems, ICD9 236 Neoplasm of uncertain behaviour of genitourinary organs and 237 Neoplasm of uncertain behaviour of endocrine glands and nervous system. In all the three cases, the excess deaths attributed to neoplasms of uncertain behaviour in years 1981-1985 were added to their respective malignant sites.

Figure 29 below shows the temporary excess coding into leukaemia of unspecified cell type, observed in the same period (1981-1985). The series was corrected by transferring 40% of leukaemia of unspecified cell type (ICD9 208) to lymphoid leukaemia (ICD9 204) and 10% to other specified leukaemia (ICD9 207).

Figure 28 Example of a posteriori correction: neoplasm of unspecified nature

- 159 Malignant neoplasm of other and ill-defined sites within the digestive organ
 235 Neoplasm of uncertain behavior of digestive and respiratory systems

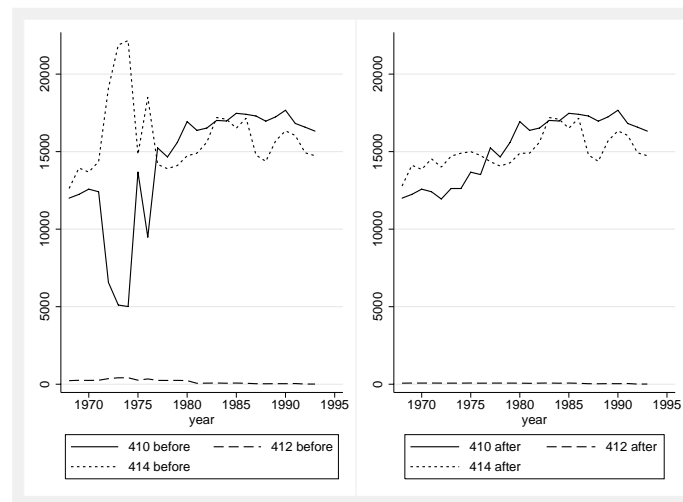
Figure 29 Example of a posteriori correction: leukaemia

- 204 Lymphoid leukaemia
 207 Other specified leukaemia
 208 Leukaemia of unspecified cell type

The most important temporary change, in the terms of death counts, took place during the period of ICD8. Between 1971 and 1972, the deaths from acute myocardial infarction dropped from 12,414 to 6,562. This drop perfectly coincided with the sudden increase of deaths coded under chronic ischemic heart disease (respective increase from 15,895 to 21,241). With an exception of year 1975, this situation lasted until 1977 (Figure 30). Obviously, the transfer resulted from a change in the interpretation of acuity of ischemic heart disease (both ICD8 and ICD9 allowed to code any myocardial infarction older than 8 weeks as chronic ischemia, and, *vice versa*, chronic ischemic heart disease specified as acute or shorter than 8 weeks could be coded as acute myocardial infarction). The change affected varying proportions of ischemic heart disease, ranging from 21% in 1976 and culminating in 1972-1973 by 34% of excess deaths (Table 21).

Another item touched by this correction was the reconstructed ICD9 item 412 Old myocardial infarction⁵². The old myocardial infarction then underwent another change in ICD9: the code 412 was extensively used during the two first years of ICD9, while in 1981 the deaths suddenly dropped from 233 to 59 and remained at low levels for the rest of ICD9. To adjust the series to these recent coding practices, we attributed 70% of deaths prior to 1981 to other forms of chronic ischemic heart disease (ICD9 414).

Figure 30 Example of a posteriori correction: chronic ischemic heart disease



- 410 Acute myocardial infarction
- 412 Old myocardial infarction
- 414 Other forms of chronic ischemic heart disease

4.3 Ill-defined causes of death

Some portion of the deaths remains, for various reasons, without diagnosis. The ICD provides specific categories for such cases - the whole ICD9 Chapter XVI refers to “*symptoms, signs, abnormal results of laboratory or other investigative procedures, and ill-defined conditions regarding which no diagnosis classifiable elsewhere is recorded*”. Moreover, within each ICD chapter there is a category for ill-defined conditions in the frame of the given group of diseases. The percentage of the so-called ill-defined causes of death often serves as a proxy indicator of the data quality.⁵³

⁵² Specified under ICD9 as medically diagnosed but currently inactive myocardial infarction.

⁵³ They are frequently used to assess the quality of cause-of-death data (Mathers et al. 2005)

Figure 31 Proportions (%) of deaths coded in the ICD9 Chapter XVI: Symptoms, signs and ill-defined conditions (items 780-799)

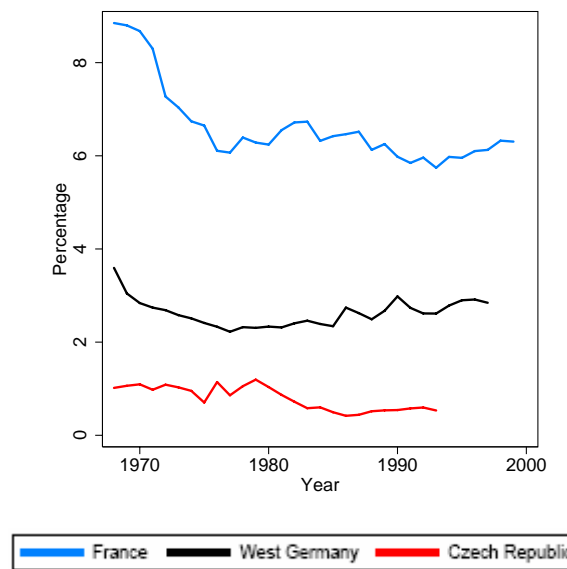
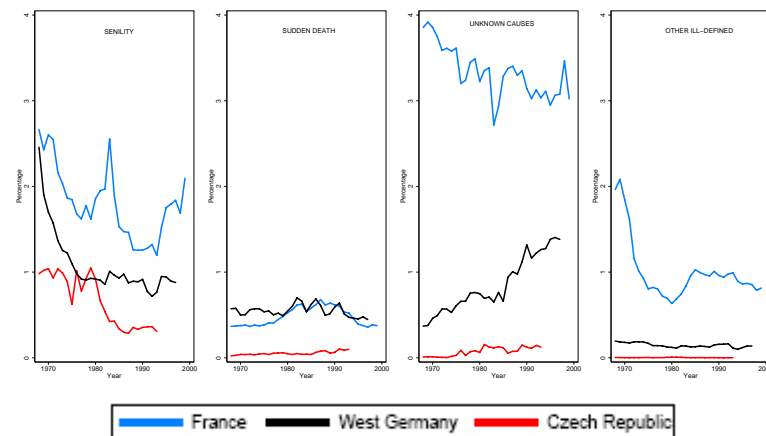


Figure 31 represents the proportions of ill-defined causes in time for Czech Republic, France and West Germany. In West Germany and Czech Republic the proportion remained stable over the entire period. In France, where the proportions were, by the end of ICD9, by far the highest (over 6% in 1999), an important decrease of ill-defined deaths occurred during the 1970s.

Out of Chapter XVI the last three ICD9 items deserve special attention: item 797 *Senility*, item 798 *Sudden death from unknown cause* and item 799 *Other ill-defined and unknown causes of morbidity and mortality*. The proportions of these categories are shown on Figure 32. The breakdown by individual ICD9 items reveals that – in all the three countries – the main improvement of the cause of death data completeness was due to the rapid decrease of reporting senility as the underlying cause of death in the elderly. France and Germany had very similar proportions of ICD9 item 798 *Sudden death with unknown cause* over the whole period.

Figure 32 also demonstrates that the excessive percentage of ill-defined causes of death found in France is explained by high levels of unknown causes (ICD9 item 799) and the rest, out of which mostly symptoms involving cardiovascular system (ICD9 785) (not shown here).

Figure 32 Proportions (%) of the three commonest ill-defined causes of death: item 797 (Senility), item 798 (Sudden death) and item 799 (Unknown cause) and the rest of ill-defined causes

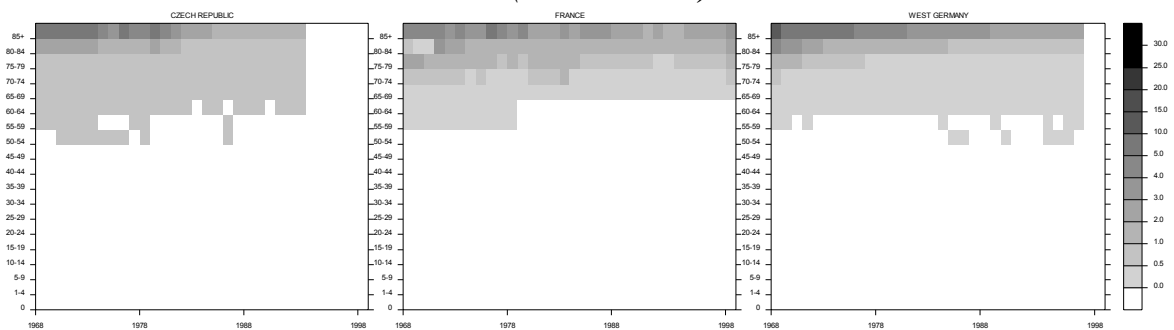


To understand the background of these major ill-defined categories, another breakdown – by age – is required. We will see that each of the three major ill-defined causes refers to specific age categories.

Remarkable improvement of cause-of-death specificity in the elderly

Figure 33 represents three relatively homogeneous yearly structures by 5-year age groups for senility. In all the three countries, improvements were the most remarkable in the oldest age groups and the trends were regular, suggesting that no (sudden) change in coding or certifying practices occurred and that we are witnessing a real improvement in cause-of-death certification of the oldest-old.

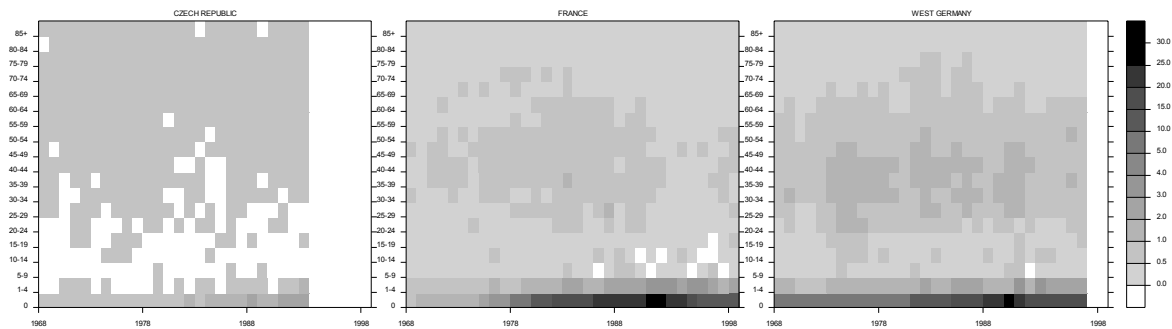
Figure 33 Proportions (%) of deaths classified as from Senility (item 797) by age, 65 years and beyond (non-linear scale)



Sudden infant death syndrome

The sudden death of unknown cause (ICD9 798) is typical by an outstanding polarity between age 0 and the rest of the age scale: the proportions of the sudden death of unknown cause are relatively low, rarely surpassing 1% for age groups 5-9 to 85+, while they may attain up to 25% for infant deaths. This phenomenon is strongly present in France and West Germany, less in the Czech Republic (Figure 34).

Figure 34 The Lexis map of the proportions (%) of ICD9 item 798 Sudden death, cause unknown from the total of the deaths by age and year, 1968-1999⁵⁴



The sudden deaths at infant age mostly account for the SIDS – sudden infant death syndrome. SIDS was first formally defined in 1969, and ICD9 was the first revision to contain SIDS as a regular classification entity (798.0). In ICD10 the SIDS has been attributed a single 3-digit code (R95) and has been excepted from the coding rule A.⁵⁵

The sudden deaths of otherwise healthy infants have always constituted a part of human mortality profile, however prior to the formalization of SIDS, it was widely believed that they were due to suffocation and caused by overlay or smothering (Bergman 1986).⁵⁶ The recent decades have then seen a remarkable increase of SIDS as a tangible medical and public health problem. The current definition of SIDS (Krous et al. 2004) reads: „*SIDS is the sudden unexpected death of an infant under one year of age, with the onset of the fatal episode apparently occurring during sleep that remains unexplained after a thorough investigation, including performance of a complete autopsy, examination of the death scene, and review of the clinical history.* SIDS is thus a diagnosis „of exclusion“⁵⁷, whose definition, classification and awareness keep changing. The diagnosis also depends on post mortem regulations and certification practices. Moreover, there are ongoing debates about the title itself – some argue that sudden unexplained death in infancy should be used instead of SIDS, because SIDS does not comply with the criteria for a syndrome. Consequently, SIDS is very prone to misclassification.

“*The classification changes also reveal more profound differences in the diagnostic and coding practices, differences much more difficult to quantify.*” [transl. from (Meslé 1995): p. 412]. The transition between ICD8 and ICD9 in both Czech Republic and West Germany revealed such differences in certifying SIDS. In both countries, the inclusion of SIDS in ICD9 increased the deaths counts without sufficient correspondence in ICD8. In West Germany, the excess SIDS deaths were previously classified as ICD8 item 776 Anoxic and hypoxic conditions not elsewhere classifiable. In the Czech Republic, the SIDS could have been classified as

⁵⁴ To construct these figures we use the program Lexis (Andreev 1999)

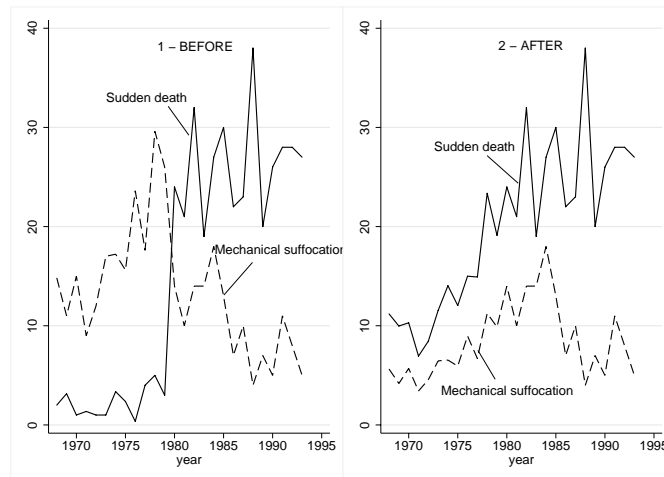
⁵⁵ Rule A in ICD10: Senility and other ill-defined conditions: Where the selected cause is classifiable to Chapter XVIII (Symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified) *except for R95 (Sudden infant death syndrome)*, and a condition classified elsewhere than to R00-R94 or R96-R99 is reported on the certificate, reselect the cause of death as if the condition classified to Chapter XVIII had not been reported, except to take account of that condition if it modifies the coding.

⁵⁶ Smothering and overlay appeared already in the infant cause-of-death list of John Graunt (Graunt 1665)

⁵⁷ A diagnostic “dustbin” (Emery 1989)

accidental mechanical suffocation (ICD8 item n° 913)⁵⁸, reflecting the low acceptance of SIDS as a diagnosis and adherence to the non-natural etiology of sudden infant deaths in sleep. The mirroring between mechanical suffocation and SIDS in the Czech Republic is shown on Figure 35. The figure shows trends before and after they were corrected a posteriori for the period of ICD8. Further corrections are possible for the early years of ICD9, but for the time being, we leave the data for a more detailed analysis of infant mortality as they are.

Figure 35 Death counts from Sudden ICD9 item n° 798 Sudden death, cause unknown and ICD9 item n° 913 Mechanical suffocation at age 0, before and after correction a posteriori, Czech Republic, 1968-1997



As the etiology of SIDS remains unravelled, ways of prevention are also limited. The "reduce the risk" campaigns against the prone sleeping position (on the belly) were launched in many countries. Correlations between these campaigns and declines in mortality were observed both in France (Barbieri 1998) and in Germany (Schellscheidt et al. 1997). In contrary, in a recent study on the US data (Malloy and MacDorman 2005) the previously recognized correlation between the "Back to Sleep" campaign and the observed decline of SIDS was put under doubt by a possible effect of death-certifiers' shift from SIDS to suffocation.⁵⁹

The users of cause-of-death data should therefore be warned from an extensive belief in the SIDS statistics: first of all due to the above mentioned problems of definition, certification and classification, but also due to the fact that the SIDS can definitively be confirmed only after a series of clinical post mortem trials and thus not appear in the statistics at the moment of their compilation.

Unknown causes: large inter-country disparities

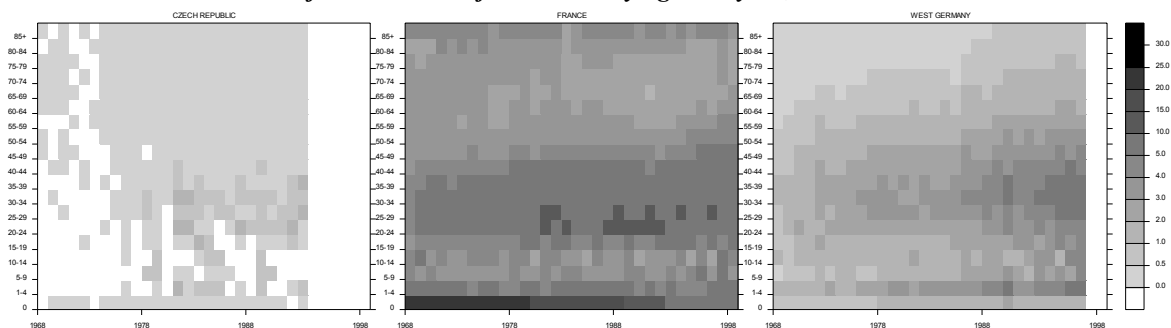
The third category (ICD9 item 799) accounts for the remaining deaths of unknown cause. The mortality from unknown causes is rising, especially for males (Figure 36). Bubenheim (2000) investigated the background of the item 799 in West Germany around year 1980. He

⁵⁸ ICD8 item 913 contained a Accidental mechanical suffocation in bed or cradle as a 4th digit item (E 913.0)

⁵⁹ Even after thorough postmortem examination, signs of accidental or intentional non-natural infant death can be missing or pass unseen by the pathologist. (Meadow 1999)

suggests that the content of this item is not independent from the cause of death, i.e. is not random and assumes that the information on cause of death can be missing if a death poses a medico-legal problem due to regional differences in the death certificate transmission (the percentage of unknown causes was extremely high in North Rhine-Westphalia when compared to other three Länder, while the death certificates were nearly the same). Our analysis of the age structure of deaths confirmed that around 1980 the diagnosis was missing primarily for deaths occurring in the mid-productive ages for both sexes (age group 25-44). However, compared to 1980, the proportions of the deaths assigned to ICD9 799 increased and substantially expanded to the whole productive age (15-65) up to present (Figure 36). With the data aggregated to the federal level and to 3-digit items we are not able to point at the regions or the specific problems behind these unfavourable trends.

Figure 36 Lexis map of the proportions (%) of ICD9 item 799 Other unknown and ill-defined causes from the total of the deaths by age and year, 1968-1999



Similar predominance of middle ages can be seen in France, suggesting that the causes of lacking information are similar in both countries: delays in transmission of information in non-natural or suspect deaths. This impression is reinforced by high proportions of unknown causes in infants. Investigations and autopsies in deceased infants are more frequent than for the rest of the populations, the definitive cause of death therefore takes longer to be found. This would provide another support the hypothesis that high proportion of unknown causes in France is due to a systemic failure – when the information about cause of death comes with a delay, it is not always included in the statistics.

Redistribution of ill-defined causes of death

Dealing with ill-defined causes of death is the final task. This step is necessary in order to eliminate the bias introduced by changing the proportions of ill-defined deaths in time, and to allow for a comparison between a greater number of countries with different proportions of ill-defined causes of death.

We have chosen to redistribute these deaths proportionally to well-defined diseases (001-779) and into accidents (E800-E999). The proportional method is fully applicable to West Germany and Czech Republic, where the share of ill-defined deaths is relatively low, the era of epidemics has passed and the time series do not show any major fluctuations. Moreover, several redistribution methods (proportional and regression method inspired by Sully Ledermann [Ledermann 1955, cit. in (Vallin and Meslé 1988)] were tested on West German data from

1981-1983 and the author concluded that the selection of the method has a minor impact on the redistribution result (Bubenheim 2000). Considering the period after 1968, the proportional redistribution is also acceptable for France, as was shown in (Meslé and Vallin 1996).

Applying the method of proportional redistribution, we assume that every death can be attributed a disease or an accident listed in ICD9 and, consequently, if the death, for some reason was not classified as ill-defined, it would have been classified under one of the ICD9 categories. At the same time, the method assumes that the decision whether the death is classified as ill-defined or not is independent of its real underlying cause (Bubenheim 2000). These assumptions are hardly true for age 0, where sudden infant deaths (especially ICD9 item 798.0, *Sudden infant death syndrome*) still occur without a known cause and occupy an important position in infant mortality. Therefore, the deaths from item 798 remain without redistribution for the first year of life.

III defined causes of death outside of the chapter XVI

Apart from the chapter dedicated to ill-defined diseases, additional ill-defined conditions are included in several regular ICD9 chapters. To give some examples Meslé (1995) mentions the ICD9 acute but ill-defined cerebrovascular disease (item 438) and proposes its redistribution into well-defined cerebrovascular accidents (p. 417-418). In the EUROSTAT report focused at the cause-of-death certification quality and comparability (Jougla et al. 2001)⁶⁰, the survey respondents were asked whether there are conditions not in ICD 9 chapter XVI (or ICD 10 chapter XVIII) that their office would consider likewise as ill-defined. Out of 20 respondents, 10 replied negatively, while the remaining countries' answers included *septicaemia, meningitis NOS, neoplasm of unspecified site and behaviour, hemiplegia, dementia NOS, rheumatic heart disease NOS, hypertension, heart failure, circulatory insufficiency, gangrene, pulmonary oedema and embolism, acute or unspecified respiratory failure, renal failure, complications of medical procedures, "secondary" conditions, or immobility*. Finally, the survey revealed that some of the countries apply the modification coding rules for these causes and some do not - creating another ground for international disparities due to coding manners.

In West Germany, one of the most important of these categories is ICD9 item 429 *Ill-defined descriptions and complications of heart disease* (shown on Figure 15). The death counts in the ICD9 category 429 decreased rapidly from 17,743 in 1980 to 4,020 in 1997, while the numbers of deaths from the remaining cardiovascular diseases in the association 138 increased. Like for the ill-defined diseases in Chapter XVII, such relatively large fluctuations may influence the trends and limit the informative value of the data, reconstructed or not. However, at this stage, we decided not to redistribute these ill-defined conditions into other categories of the appropriate chapter. First of all, apart from ICD9 item 429, they are negligible in death counts. Second, the assumption of independence between coding to well-defined and ill-defined conditions of one chapter is disputable. To give an example: the irregularity of the ICD9 429 trend probably arises from a change in coding instructions – as of 1980, a part of the ICD9 429 deaths were to be coded to another category. With the present data, we are not able to reveal the

⁶⁰ Online at http://europa.eu.int/comm/health/ph/programmes/monitor/fp_monitoring_1998_frep_04_en.pdf

exact character of this interchange and therefore prefer to avoid speculations and leave the data as they are. This issue can be better examined in the framework of in-depth studies on cardiovascular diseases.

Chapter IV.

Transition to ICD10

ICD10 came into effect in 1993. The Czech Republic was among the first ones to adopt, Germany adopted it for the mortality statistics in 1998 and France two years later in 2000. Updating the existing series to ICD10 was thus the next logical and indispensable step in examining the recent mortality trends by cause of death. To our knowledge, no one so far tried to apply the a posteriori reconstruction method to the ICD10 data. We attempted to do so for the West Germany, but during the work, we encountered numerous problems that have led to the reconsideration of the applied methodology. This chapter first provides more information about the ICD10 itself and, second, describes the method finally used to reconstruct the series up to comply with current ICD10 structure and coding rules.

5.1 More about ICD10

The basic features of ICD10 have been presented in Chapter II - the introduction of an alphanumeric system of codes, increase of the classification detail (from cca 5.000 to approximately 8000)⁶¹, changes in the chapter structure and important moves across the classification.

The major impact on continuity is however due to the change in the coding rules, notably the Rule 3 (the first filter to all previous selections).⁶² The wording and the structure of the selection rules are similar to ICD9. Critical is the fact that the rules became more precise and allowed to recognize numerous diseases as being consequences of others. The main change concerns diseases listed by the Rule 3 and most typically manifests in reassigning deaths that would have previously been coded as *pneumonia* to other paralysing or wasting diseases

⁶¹ In total, ICD10 contains about 12.700 categories, but not all of them are valid as code for cause of death.

⁶² While all the death certificates, including the correctly filled ones, pass through all the selection and modification rules

(typically circulatory diseases, diabetes, Alzheimer disease), because pneumonia is listed as a direct consequence of virtually any disease under ICD10. As a consequence, a dramatic drop in pneumonia is expected in most of the countries adopting ICD10. On the other hand, we can expect an increase of deaths from septicaemia, which is in ICD10 rules given preference over pneumonia⁶³, and an increase of AIDS, which in ICD10 rules can provoke any cancer or infection. SIDS (sudden infant death syndrome) has been excepted from Modification rule A and as it is no more considered an ill-defined cause, it is therefore more likely to be selected as underlying cause of death. Selection of the primary site of cancer was also largely affected by redefining the pathological causalities and although the group of neoplasms is not affected by the ICD10 as a whole, there may be substantial structural shifts within the chapter.

5.1.1 Manual versus automated coding

Hand in hand with new coding rules come the new automated coding systems. In countries with manual coding, the trained coders (or medical doctors) first assign ICD codes to the diseases listed on the death certificates. The underlying cause of death is then selected by the coders at the respective health (or statistical) offices. Manual coding is therefore, inherently, partially subjective - dependent on the coders personality, professional experience, etc. It has been reported that manual coding also systematically tends to select severe conditions, typically cancer, as underlying cause of death (Percy and Dolman 1978). And finally, with implementation of new revision and new coding rules, the coding apparatus takes some time to adapt; this „learning effect“ manifests in sudden or gradual shifts in the data visible shortly after implementation of a new revision.

The first attempts of automating the cause-of-death data processing date back to late 1960s. In 1968, NCHS (National Center for Health Statistics) developed a system for selecting, in accordance with the current ICD rules, the underlying cause of death from the ICD codes of diseases entered on the death certificate. The system is known as ACME (Automated Coding of Medical Entities) and went on to become an international standard.

The contemporary automated coding systems are two-stage. After ACME, several systems were developed to encode the original text information entered by the certifying practitioner into a valid ICD code. Some countries, mainly English speaking, have directly adopted another NCHS system called MICAR (Mortality Medical Indexing, Classification, and Retrieval), later enhanced by SuperMICAR, but many countries, mainly due to language difficulties, developed their own systems or decided to use a combination of their proper system with MICAR to feed the ACME decision tables.⁶⁴ The implementation of automated coding has certainly positive effects on the international comparability of mortality data, but may be so disrupting that a bridge coding is recommended to assess its impact. The manner of coding definitely plays an important role when a new ICD revision is implemented.

⁶³ (Anderson et al. 2001)

⁶⁴ Sweden developed MIKADO, France STYX, United Kingdom TRACER, Spain DECES, to cite a few.

5.1.2 Bridge coding studies – useful predictor of expected troubles?

The serious risk of introducing data discontinuities was partially the reason why the number of countries performing the double-coding increased considerably with ICD10. Not surprisingly, most of these countries employ an automated coding system. Table 22 gives an overview of the major bridge-coding studies conducted for ICD10, and a list of published materials.

Table 22 Summary of the bridge coding studies between ICD9 and ICD10

Country	Sampling	Sample size	ICD9 coding	ICD10 coding	Data	ICD change	Publication
USA	80% random	2318212	MICAR/ACME	MICAR/ACME	1996	1999	(Anderson et al. 2001)
Canada	Selected regions	81600	MICAR/ACME	MICAR/ACME	2000	1999	(Geran et al. 2005)
E&W	100 %	551093	TRACER/MICAR/ACME	TRACER/MICAR/ACME	1999	2001	(Rooney et al. 2002)*
France	10% random	53869	Manual	STYX/ACME	1999	2000	(Pavillon et al. 2004)
Italy	100% in 2 months	96451	MICAR/ACME	MICAR/ACME	2003	2002	NA
Spain	Sel. regions, 24% of total deaths	88084	Manual	Manual	1999	1999	(Ruiz et al. 2002)
Sweden	25% random	25440	manual/ACME	MIKADO/ACME	1996	1997	NA

*a series of reports focused on specific groups of diseases was published

There is no standardized procedure for the bridge coding, the above cited studies therefore differ in many aspects – sampling method, sample size, the detail of published results. A common output of the bridge coding are the comparability ratios, calculated by dividing the number of deaths coded to cause i in ICD10 by the number of death coded to cause i in ICD9.

$$C^i = \frac{D_i^{ICD10}}{D_i^{ICD9}}$$

The cause i is *a priori* defined using a given tabulation list, such as European shortlist of 65 causes of death (by EUROSTAT) or a 113 items list for USA and Canada. Correspondences given in these shortlists are often, in order to be as simple as possible, broadly defined. The interchapter exchanges, as well as other structural changes, are frequently disregarded. Consequently, the comparability ratios measure the impact of both the structural changes and the application of the coding rules. In France, the coding of cause of death passed from manual to automatic at the moment of ICD10 implementation, the resulting comparability ratios therefore have an additional dimension – the effect of automated coding.

Discussing the detailed results of the individual bridge coding studies is not in scope of this paper, it is however useful to gather the main results to give an overall idea about the impact of ICD10 across several countries. The results are displayed in Table 23.

Table 23 Comparability ratios by ICD10 chapters – results from bridge coding studies

ICD10 Chapt er	ICD10	ICD9	Title	France	Canada	England & Wales	Spain	Italy
I	A00-B99	001-139	Certain infectious and parasitic diseases	1,38	1,08	1,10	1,36	1,30
II	C00-D48	140-239	Neoplasms	1,01	1,01	1,03	1,01	1,01
III	D50-D89	280-289	Diseases of the blood and blood-forming organs and certain disorders involving the immune mechanism	0,86	0,91	0,65	0,67	0,86
IV	E00-E90	240-279	Endocrine, nutritional and metabolic diseases	1,13	1,04	1,05	0,86	1,06
V	F00-F99	290-319	Mental and behavioural disorders	1,09	0,84	1,22	NA	0,80
VI	G00-G99	320-359	Diseases of the nervous system	1,25	1,33	1,50	1,33	1,15
VII	H00-H59	360-379	Diseases of the eye and adnexa			1,00		
VIII	H60-H95	380-389	Diseases of the ear and mastoid process			0,71		
IX	I00-I99	390-459	Diseases of the circulatory system	1,00	0,99	1,04	0,97	0,97
X	J00-J99	460-519	Diseases of the respiratory system	0,86	0,85	0,77	1,05	0,97
XI	K00-K93	520-579	Diseases of the digestive system	0,93	1,02	1,01	1,00	0,96
XII	L00-L99	680-709	Diseases of the skin and subcutaneous tissue	0,86	1,05	0,99	1,09	1,30
XIII	M00-M99	710-739	Diseases of the musculoskeletal system and connective tissue	1,09	1,36	1,39	1,07	1,37
XIV	N00-N99	580-629	Diseases of the genitourinary system	0,94	1,01	1,00	1,00	1,08
XV	O00-O99	630-676	Pregnancy, childbirth and the puerperium	1,50	NA	1,10	1,00	NA
XVI	P00-P96	760-779	Certain conditions originating in the perinatal period	1,03	1,03	NA	1,06	NA
XVII	Q00-Q99	740-759	Congenital malformations, deformations and chromosomal abnormalities	1,08	0,91	NA	1,00	NA
XVIII	R00-R99	780-799	Symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified	0,93	1,00	1,00	1,14	1,47
XX	V01-Y89	E800-E999	External causes of morbidity and mortality	0,96	1,02	1,01	1,00	0,94

Even on the aggregated level of ICD chapters, the ICD9/ICD10 continuity is not assured and the results are not consistent across countries, in some case even reverse trends are observed. Infectious and parasitic diseases increased with ICD10 implementation in all countries due to recognition of HIV as underlying cause of death for many diseases including some cancer, and due to increased selection of septicaemia. The most stable is, traditionally, the coding of cancer: in all studies the comparability ratios were close to 1. A consistent drop was also observed for diseases of the blood and blood forming organs (chapter III), due to addition of myelodysplastic syndromes to neoplasms. Endocrine, nutritional and metabolic diseases were selected more frequently in all countries except Spain. This increase was explained by

application of rule 3 for diabetes, in Spain the authors consider the decrease as due to exclusion of AIDS (previously classified under 279 in ICD9) (Ruiz et al. 2002). Quite varied are the results for mental and behavioural disorders. Only in France and in England and Wales an increase was observed, attributable to change in Rule 3 allocating more deaths to dementia. The source for decrease of deaths classified to the chapter of mental disorders is that the ICD10 rules tend to code deaths from liver disease linked with alcoholism, which would have been coded to alcohol dependence syndrome in ICD9, to the chapter of digestive diseases. There is also a tendency to reassign majority of deaths from presenile dementia (290.1) to Alzheimer disease (G30), which decreases numbers of deaths in chapter V and, combined with impact of Rule 3, manifests in a general important increase for the whole chapter of nervous diseases (chapter VI).

Comparability ratios for cardiovascular diseases, the most important chapter in the terms of death counts, oscillate around 1, suggesting that the coding for a chapter as a whole remained comparable. The slight increases and decreases were observed, the reasons for the both-ways movements cited by the authors of the respective bridge-coding studies are the following: 1) the cardiac arrest is considered an ill-defined cause in ICD10 and therefore is not selected if another more specific cause is present anywhere on the certificate; 2) rule 3 gives preference to cerebrovascular diseases over pneumonia; 3) transient cerebral ischemia moved from cerebrovascular diseases to chapter VI in ICD10. As expected, the respiratory diseases drop under ICD10 due to application of rule 3. In Spain no such drop was observed at the level of the chapter, however in the publication the authors claim that the trend for pneumonia alone was comparable to the rest of the bridge-coding studies (Ruiz et al. 2002). The digestive diseases did not show big variation, some deaths classified previously as alcoholic dependence syndrome (ICD9 303) may now be in alcoholic liver disease and, in contrary, some deaths from chronic hepatitis (ICD9 571.4) can be attributed to the chapter of infectious diseases in ICD10. The deaths attributed to the chapter of musculoskeletal and connective tissue diseases increased in all countries due to the already mentioned inclusion of gout and polyarteritis nodosa. The chapter of accidents was not seriously impacted by ICD10, there have however been important movements within, especially for accidental falls.

5.1.3 ICD Translator

In 1997, the WHO released a unique tool to ease the transition to ICD10: the ICD-9/ICD-10 Translator, a set of electronic tables indicating equivalent disease codes for the translation of ICD-9 to ICD-10 and vice-versa (WHO 1997). ICD translator covers all items of ICD, including complementary classifications, down to the detail of the 4-digit.⁶⁵ Trying to make maximum use of this official document, we aggregated the ICD Translator data to the 3-digit level and automatically created elementary associations. A total of 292 associations were obtained, out of which the first association gathered 702 (53%) out of a totality of 1333 items and the second one gathered 100 (13%).⁶⁶ For some items the correspondences in ICD Translator are not

⁶⁵ Prior to ICD Translator, the Department of Medical Informatics in Freiburg has attempted to produce a similar document specific for West Germany (Zaiss et al. 1996) After release of ICD Translator, these files were updated (after update 90% of correspondences is identical to ICD Translator) (Zaiss et al. 1999)

⁶⁶ The attempt ended at this stage, we did not investigate how many percent of deaths fell in these large associations.

defined at all. The translator can therefore only serve as a (very) good base to search for appropriate correspondences.

In the next step, we attempted to create the elementary associations manually and to work at the 3-digit level in the same way as for ICD8/ICD9. This method was finally abandoned too, because in many cases the 3-digit level is not enough and extending the application to the level of the 4th digit, moreover for the three countries in question, was far beyond the scope of this thesis.

5.2 Rethinking the methodology

To summarize, the gain in detail and changes in coding rules reflect the intention of WHO to increase the precision and the usability of ICD, which is therefore more and more heading on to become a multi-purpose medical classification. The observed discontinuities are thus but a logical side-effect of such change. This nature of ICD10 makes the transition much more problematic than in the previous change from ICD8 to ICD9, due to several reasons. First: unlike for ICD8/ICD9, in many cases the 3-digit ICD detail is not sufficient; second: due to fundamental changes in the rules for selecting the underlying cause of death, in absence of bridge coding, we can only guess what kind of exchange took place for the cause of death with unexpected trend, and third: unlike for automated coding systems, the manual coding systems adapt to the new classification progressively, the obtained time series are finally not necessarily in accordance with the most recent coding practices and in some case a posteriori correction even within the ICD10 can be considered.

For the purpose of this thesis, we decided to realize the abridged transition to ICD10 via creation of a multi-purpose shortlist.

5.2.1 Data

The following data were available for the reconstruction to ICD10:

- 1) For the Czech Republic, data were obtained from a series of deaths by cause published in an electronic format at the website of the Czech Statistical Office.⁶⁷ The Czech data are the most recent from the file, ranging up to 2008. On the other hand, at the 3-digit level and with the last open age interval is 85+, not providing too much detail about the cause-specific mortality of the oldest old.
- 2) For the West Germany, data until 2006 were available at the 3-digit level, ending at open age interval 90+. Nevertheless, the ICD10 data provided by the German Statistical Office do not cover the same territory as for the previous ICD revisions while Berlin is no more divided into East and West. In 2001 the district reform merged the former 23 Berlin districts into 12 new districts (Scholz and Jdanov 2005). Two of the new districts (Mitte and Friedrichshain-Kreuzberg) are a mixture of formerly East and West Berlin, which does not allow for distinction between East

⁶⁷ [http://www.czso.cz/csu/2007edicniplan.nsf/publ/4017-07-\(1919_az_2006\)](http://www.czso.cz/csu/2007edicniplan.nsf/publ/4017-07-(1919_az_2006))

and West Berlin anymore. Max Planck Institute for Demographic Research recombined the official data from the statistical office with data from the registry office (*Melderegister*) in Berlin: these data kept the former territorial structure until 2004. Until 2004 we could use these reconstituted all-cause death counts to proportionally adjust the cause-of-death data. The solution for data beyond 2004 is still in question.

- 3) For France, the data cause-of-death were obtained during the author's stay at the 5th research unit of INED (MSE – Mortalité, santé, épidémiologie). The ICD10 data cover years 2000-2006, provide the 4th digit detail and age-cause-specific information until age group 105+. The original age format of the data was, however, changed in order to comply with the age format of the reconstructed ICD9 time series (see chapter IV).

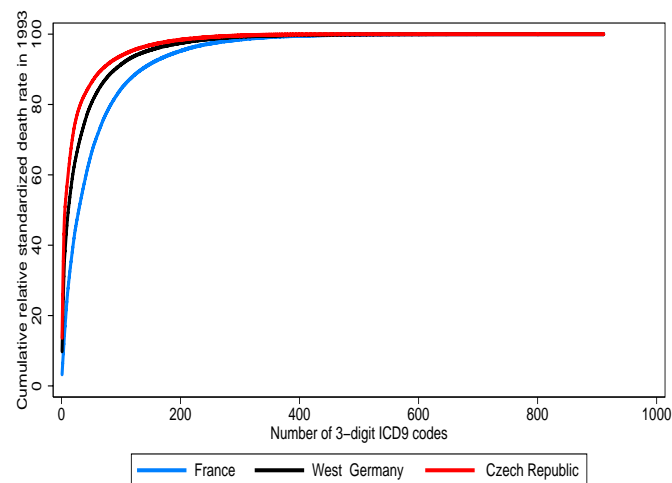
Table 24 Summary of the ICD10 data

Country	Range	Detail	Age group format
Czech Republic	1994-2008	3-digit	0,1-4,5-9,...,85+
West Germany	1998-2004	3-digit	0,1-4,5-9,...,90+
France	2000-2006	4-digit	0,1-4,5-9,...,105+

5.2.2 Creating the shortlist

Statistically speaking, due to the nature of ICD mortality coding, the overall mortality is contained in only one half of the ICD items. Moreover, around 90% of mortality is concentrated into only 100-150 causes of death (depending on the country profile). After reaching 90%, the marginal explanatory value of each added ICD item quickly decreases (see the number of ICD9 items plotted against the cumulative relative age-standardized mortality rates contained in them - a representation analogous to Lorenz curve (Figure 37).

Figure 37 Concentration of mortality into 3-digit ICD9 items



Although these approximately 150 causes of death are enough to explain the overall mortality, the shortlist cannot be derived solely based on the statistical frequency of ICD codes. To assure for the maximum informative value, an „intelligent“ cause-of-death shortlist must contain also diseases with specific public health impact, even if they are marginal in death counts. Such list should:

- 1) allow for smooth linking between ICD9 and ICD10,
- 2) assure for maximum comparability between countries,
- 3) suit the current shortlists in use,
- 4) respect the historical epidemiological context,
- 5) keep the most of explanatory information.

Smooth transition is the primary purpose of the proposed list. The shortlist items are attributed the “best practice” ICD9/ICD10 correspondences based on the ICD Translator, existing lists, the previous 3-digit attempt for West Germany and complementary information from the bridge coding studies. Distinction is kept for causes which changed the chapter: myelodysplastic syndromes, non-specific lymphadenitis, adult osteomalacia, gout, polyarteritis nodosa, and transient cerebral ischemia.

The proposed list should also be applicable directly to the 3-digit data format and contain correspondences to ICD10. As “shortlists in use“ we consider: ICD9 basic tabulation list (BTL), “European shortlist” of 65 causes (by EUROSTAT), the NCHS list of 113 selected causes of death (Anderson et al. 2001), and a shortlist proposed by Vallin and Meslé (1988).⁶⁸ Another list to be taken under consideration is the concept of avoidable causes of death, used in the literature to assess the performance of health care system (Nolte and McKee 2004), and the concepts of smoking- (Colditz 2000) and alcohol attributable mortality (Ridolfo and Stevenson 2001) – to give an example.

Special approach: France

It has been mentioned above that when France adopted the 10th ICD revision, it also changed from manual to automated coding, using its proper encoding tool Styx and ACME decision tables. Due to these two concurrent changes, the impact of ICD10 to the French cause-specific mortality data has been more important than for other two countries and the results obtained by the abridged transition via the shortlist proposed in the next section were far from satisfactory.

At the same time, a bridge coding was performed on a sample of death certificates by INSERM (Pavillon et al. 2004). This double coding was therefore used to be tested for convenience in reconstructing the time series. In the first step, the data were grouped into the level of 3-digit items. Next, the transition coefficients were computed as proportions of ICD9 items by their corresponding ICD10 items, separately for age 0 and the rest of the age scale. These coefficients were then applied to the whole ICD8/ICD9 series covering the period 1968-

⁶⁸ Their shortlist is presented in ICD8, we consult it therefore only approximately.

1999 and reconstructed via the a posteriori double classification at the 4th digit level (Meslé and Vallin 1996).⁶⁹ In the next step, the data were collapsed into the proposed shortlist.

One big limitation of the French double coding is its size – the file contains a bit less than 54000 deaths, which constitute only 10 % of the overall deaths occurring in France in 1999. As a consequence, some of the less frequent causes are not present in the sample at all. For these causes, the series were reconstructed based on the correspondences given in the shortlist proposed below. In graphic presentations of the reconstruction of selected diseases, both results for France (obtained by the shortlist and by the double coding) will be shown for comparison.

5.2.3 Results of the abridged reconstruction to ICD10

Considering the above criteria, we ended up with a list of 186 items, which can also directly reshape the data into the NCHS 113 list, into the 65 European shortlist, into the list of avoidable and smoking-attributable causes of death. The following paragraphs describe, by main chapters of ICD, the rationale for including concrete causes of death in the shortlist and discuss the proposed correspondences between ICD9 and ICD10 and present the results of selected transition. In some cases, the list was not able to remove comparability issues introduced by the change of coding in West Germany and Czech Republic. In these cases, further corrections a posteriori were applied and will be mentioned along with the presented results. As additional information, the tables with listed shortlist items are shaded according to the number of countries where problems with transition were observed: for one country the shading is 10% of grey, for two countries 20% of grey and for three countries 30% of grey. The most problematic causes are then systematically selected as examples.

Concerning the Czech Republic, for many diseases a break in continuity occurred in 2007. These breaks were not accidental: in 2006-2007 the Czech Republic participated in a European Commission Transition Facility Multi-Beneficiary Programme for Statistical Integration programme (Štyglerová 2008). This project of cause-of-death statistics improvement aimed to increase the quality of both certification and coding of causes of death. For the coding part, it mainly dealt with the removal of the coding rules which did not comply with current WHO recommendations. For some causes the observed changes reflected the rectification of long-term coding habits, while some breaks were related to a lately adoption of ICD10 coding rules. The question of how to evaluate these breaks is not straightforward and bears elements of subjectivity. We distinguished these delayed effects connected to ICD10 in the Czech Republic only if similar breaks in one of the two remaining countries were observed at the moment of ICD10 adoption. For these causes, we add 10% of grey to the scale as for the Czech Republic, even if the transition problem occurred with 13-years delay. The concrete cases are mentioned in the appropriate chapter.

Infectious diseases

The existing shortlists usually reduce the chapter of infectious diseases into few items. Thus, the European shortlist, adapted to the needs of the developed countries, keeps only four

⁶⁹ The coefficients were not applied to AIDS death prior to 1983.

positions for infections (TBC, meningococcal infection, AIDS and viral hepatitis). Vallin and Meslé (1988) divide infectious diseases into typhoid and paratyphoid fever, tuberculosis (respiratory and other), syphilis and other STD, other intestinal infectious diseases, other bacterial diseases, other viral diseases and other infectious diseases. The NCHS 113-list additionally distinguishes salmonella, dysentery, whooping cough, septicaemia, measles, acute poliomyelitis, scarlet fever and malaria.

The 186-shortlist holds 25 positions for infectious diseases. It contains the classical infectious diseases (typhoid fever, TBC, syphilis, measles, ...), the vaccine-preventable diseases (whooping cough, diphtheria, tetanus, polio), allows for distinction between bacterial, viral and other etiology, respects the need of surveillance the (re-)emerging infections (AIDS, malaria, slow viral infections, mycoses,...) and keeps potentially problematic diseases apart (Table 25).

Table 25 186-shortlist, part I: infectious diseases

List number	Title	Category codes according to ICD9	Category codes according to ICD10
001	Typhoid and paratyphoid fevers	002	A01
002	Other salmonella infections	003	A02
003	Other food poisoning (bacterial)	005	A05
004	Dysentery	004, 006	A03, A06
005	Other intestinal infections	001, 007-008	A00, A07-A08
006	Ill-defined intestinal infections	009	A09
007	Respiratory TBC	010-012	A15-A16, J65
008	Other TBC	013-018	A17-A19
009	Diphtheria	032	A36
010	Whooping cough	033	A37
011	Meningococcal infection	036	A39
012	Tetanus	037	A35
013	Septicaemia	038	A40-A41
014	Syphilis	090-097	A50-A53
015	Other bacterial diseases	020-031, 034-035, 039-041, 098	A20-A34, A38, A42-A43, A48-A49, A54
016	HIV disease	042-044	B20-B24
017	Acute poliomyelitis	045	A80
018	Slow viral infection of nervous system	046	A81
019	Measles	055	B05
020	Viral hepatitis	070	B15-B19
021	Other viral diseases	047-054, 056-066, 071-079	A82, A85-A89, B00-B04, B06-B09, B25-B34
022	Malaria	084	B50-B54
023	Mycoses	110-118	B35-B49
024	Other and unspecified infectious diseases	136	B59, B89, B99
025	Other infectious and parasitic diseases	080-088, 099-104, 118-135, 137-139	REST 1

Infectious diseases in chapter I are mostly easy to reconstruct over ICD revisions, while their etiological agents have long been known. In contrary, as the bridge coding studies suggested, some of the included items are potentially problematic. First case is septicaemia, which formally belongs to the group of bacterial diseases, but its evolution is completely

different – a consistent rise, accentuated by the implementation of ICD10, has recently occurred in all the three countries. In France, due to the switch to automatic coding procedures, the increase was immediate. In West Germany and the Czech Republic septicaemia deaths increased as well, but later (probably due to delayed application of new coding rules by the manual coding systems). The second case is then viral hepatitis.

To evaluate the result of the transition to ICD10 in West Germany, we depict these potentially “problematic” causes of death from several bridge coding studies (Table 26).

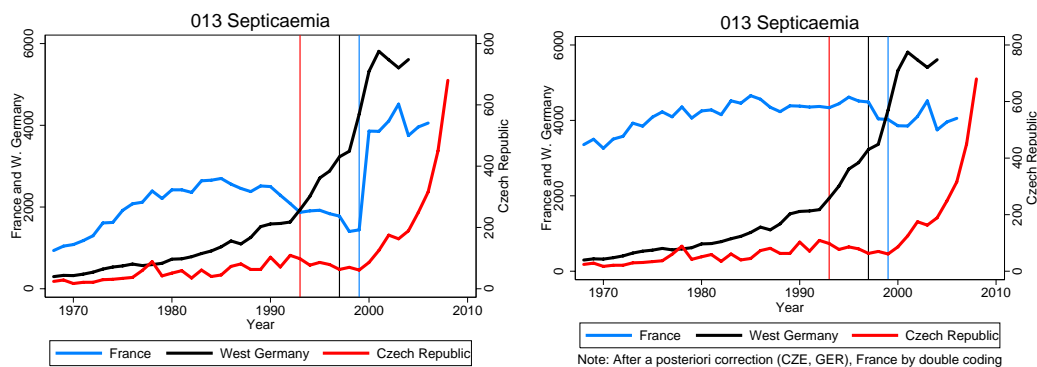
Table 26 Comparability ratios for selected causes of death in different countries

ICD10	ICD9	Title	France	USA	Canada	E&W	Italy
A40-A41	038	Septicaemia	2,70	1,19	1,24	1,11	1,55
B15-B19	070	Viral hepatitis	4,50	0,83	0,87	1,11	NA

The comparability ratios for septicaemia vary from 1.11 to 2.70. In the bridge coding studies, the rise of septicaemia mortality is unanimously explained by change in Rule 3, according to which septicaemia is given preference when both septicaemia and pneumonia are present on the death certificate. In France, 30% of the observed increase was due to inclusion of non-specific infections (ICD9 136.9).

Septicaemia is a medical term employed for the presence of pathogenic organisms in the bloodstream, and unlike for other bacterial diseases, septicaemia thus represents rather a way of death than a cause of death. According to the recent medical attitudes, the use of septicaemia as a term is problematic and should be avoided (Bone et al. 1992). On the other hand, septicaemia contains codes for cases, where patients are infected by antibiotic-resistant drugs (most typically MRSA - methicilline-resistant staphylococcus aureus), while so far, ICD does not allow for distinction of this type of infection. Antimicrobial resistance is an emerging issue in medicine and the proportions of resistant pathogens in septicaemia have been found to underlie the observed increase in septicaemia mortality in England and Wales (Crowcroft and Catchpole 2002). The future keeping of septicaemia as a separate category will thus enable to evaluate the impact of these new aspects of mortality.

Figure 38 Reconstruction result for Septicaemia

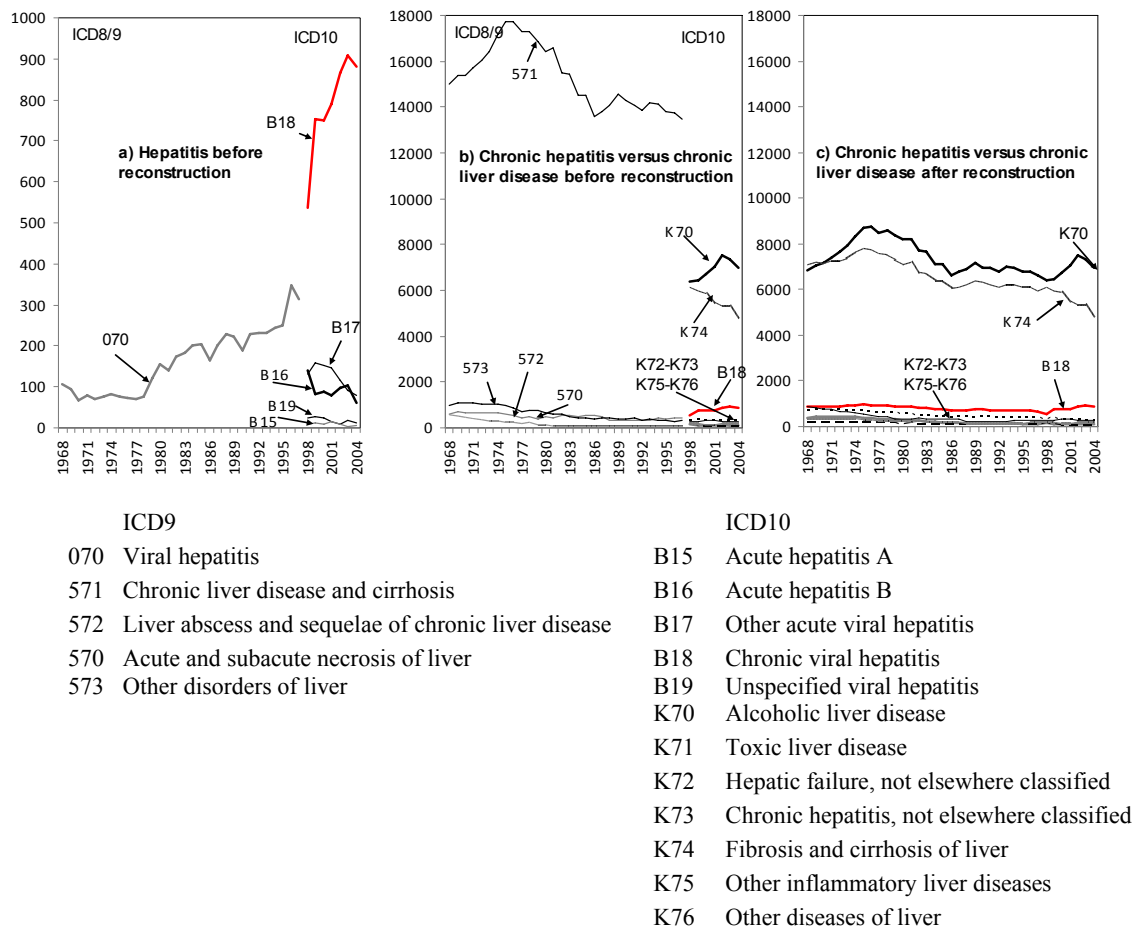


The Figure 38 shows that the ICD10-induced increase of deaths from septicaemia was gradual in the West Germany and the Czech Republic, contrasting to the sudden increase in

France, which completely levelled-off by application of the double-coding transition coefficients.

The comparability ratios of viral hepatitis indicate movements in both directions, with an extreme case of a 4.5fold increase for France (Table 26). In the countries where deaths from hepatitis dropped (USA, Canada), the provided explanation was to reflect another change in Rule 3 – the recognition of AIDS as the underlying cause for numerous infections.

Figure 39 Reconstruction result for viral hepatitis in West Germany (full 3-digit level)



Note: The first figure shows only *infectious* hepatitis before reconstruction and uses 18x smaller yaxis scale than the remaining two.

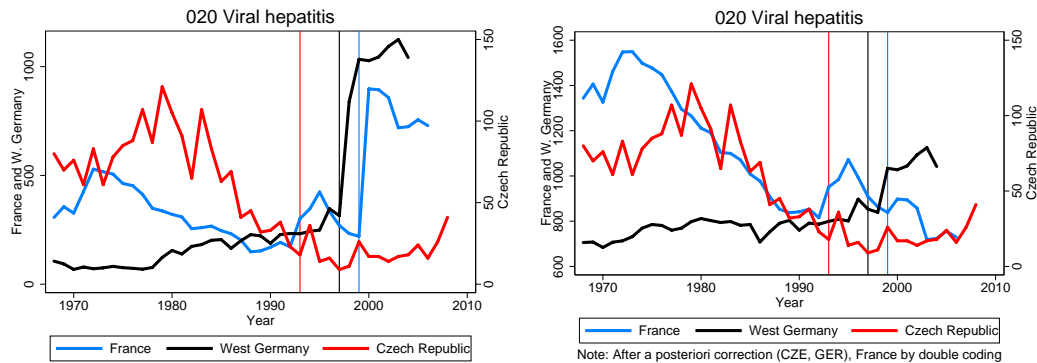
In France, majority of the remarkable increase of viral hepatitis was due to its previous misclassification in the chapter of digestive diseases (as ICD9 item 571.4 chronic hepatitis) (Pavillon et al. 2004). Even though the WHO manual explicitly stated not to classify any acute or chronic hepatitis of infectious origin under 571.4⁷⁰, these recommendations were obviously not respected neither in France nor in West Germany. Therefore, the chronic viral hepatitis (B18) was associated with the chronic liver disease and cirrhosis (ICD9 571), assuming that

⁷⁰ Extracted from ICD9 manual: 571.4 *Chronic hepatitis*. Excludes: viral hepatitis (acute) (chronic) (070.0-070.9). Accordingly, ICD Translator only gives Viral hepatitis (ICD9 070) as the only source for deaths classified under B15-B19 in ICD10.

similar exchange as in France took place in West Germany (Figure 39) and the resulting coefficients were used to reconstruct viral hepatitis in West Germany.⁷¹

Figure 40 finally shows the result of the reconstruction of viral hepatitis in all the three countries before and after application of correction or double coding.

Figure 40 Reconstruction result for viral hepatitis



Cancer: stable coding across ICD revisions

Malignant neoplasms are, traditionally, the most reliable causes of death. Several ICD9 and ICD10 based studies have reported agreement of manual cancer coding over 80% (Giersiepen and Greiser 1989; Jahn et al. 1995; Jedrychowski et al. 2001).⁷² The stability of the definitions of cancer was also confirmed by our experience from previous ICD transitions.

Diverse cancer localizations have diverse tendencies, and although the mortality from cancer as the whole chapter does not seem to evolve dramatically, the movements within the chapter are important and have high informative value.

The proposed shortlist (Table 27) reserves 30 items for malignant neoplasms allowing for distinction between smoking/alcohol related, avoidable, and/or public-health relevant cancer localizations. Furthermore, several “garbage codes”⁷³ are kept in order to assess the coding quality and comparability. These are: the malignant neoplasms without (shortlist item 052), with ill-defined (shortlist item 053) and, especially, with multiple independent sites (shortlist item 054 consisting of the above mentioned ICD10 item C97, which has no analogous code in ICD9).

The specified cancer sites (shortlist items 026-051 and 055) passed mostly unaffected to ICD10.⁷⁴ On the other hand, the ICD10 revealed substantial diversity in coding of unspecified cancer – the differences are striking for case of transition to ICD10 in France and diverse international practices in coding of these neoplasms come in the full view as well (Figure 41).

⁷¹ The transition is actually not quite satisfactory, while without the 4th digit detail, we cannot separate the chronic hepatitis (571.4) from the chronic liver disease and cirrhosis (571) to obtain a more realistic trend which would not just copy the overall evolution of the ICD9 item 571

⁷² In systems with automated coding, the agreement is even higher

⁷³ The term employed by (Mathers et al. 2005)

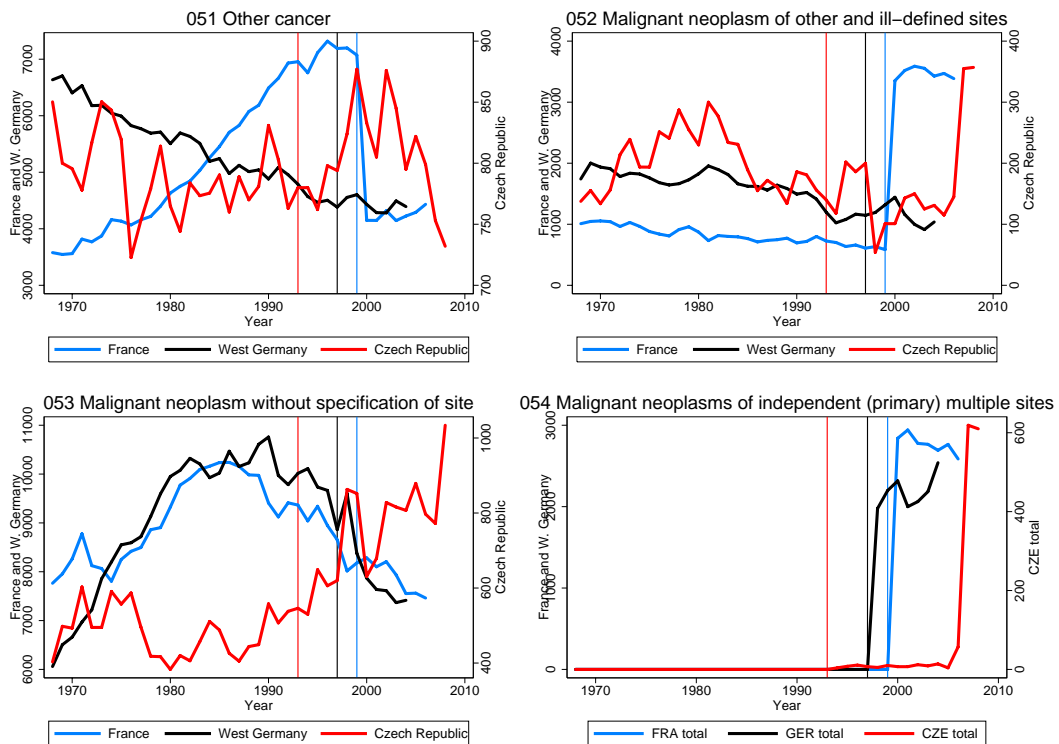
⁷⁴ Štyglarová however points out that prior to the project of coding quality improvement, extensive preference was given to code cancer regardless of its order on the death certificate and that the recent improvement in coding may have, to a small extent, underlied the observed decrease in cancer mortality.

Table 27 186-shortlist, part II: malignant neoplasms

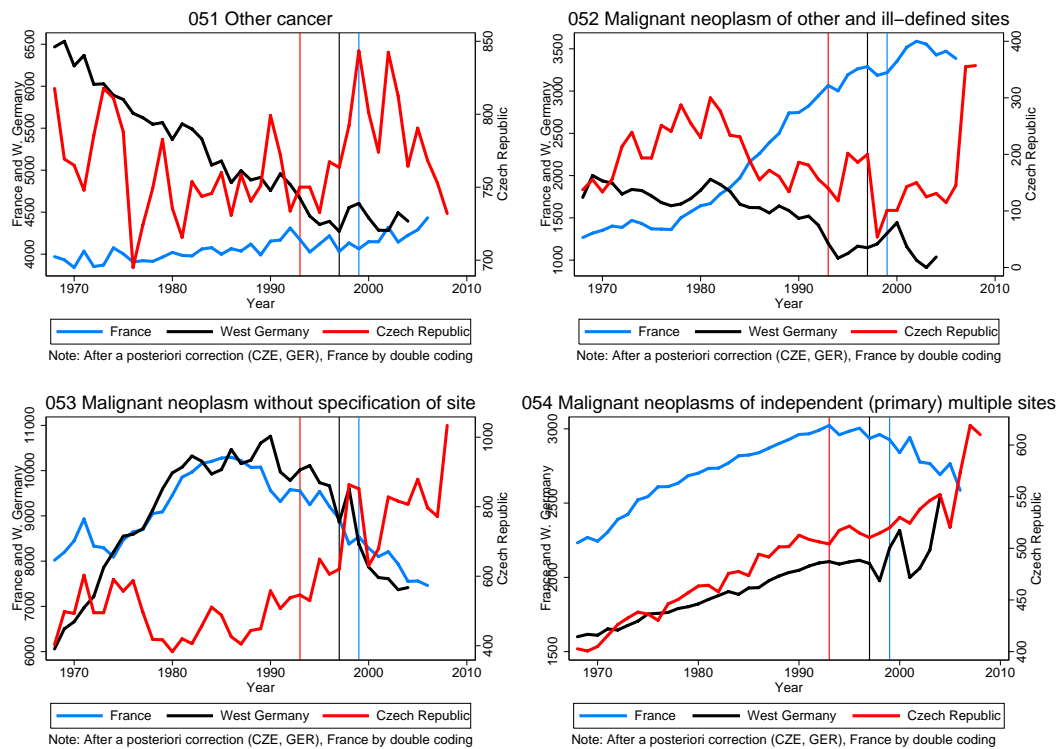
List number	Title	Category codes according to ICD9	Category codes according to ICD10
026	Malignant neoplasms of lip, oral cavity and pharynx	140-149	C00-C14
027	Malignant neoplasm of esophagus	150	C15
028	Malignant neoplasm of stomach	151	C16
029	Malignant neoplasms of colon	153	C18
030	Malignant neoplasm of rectum and anus	154	C19-C21
031	Malignant neoplasms of liver and intrahepatic bile ducts	155	C22
032	Malignant neoplasm of pancreas	157	C25
033	Other malignant neoplasm of digestive system	152,156,158,159	C17,C23-C24,C26,C48
034	Malignant neoplasm of larynx	161	C32
035	Malignant neoplasms of trachea, bronchus and lung	162	C33-C34
036	Malignant melanoma of skin	172	C43
037	Malignant neoplasm of skin	173	C44
038	Malignant neoplasm of breast	174,175	C50
039	Malignant neoplasm of cervix uteri	180	C53
040	Malignant neoplasms of corpus uteri and uterus	179, 182	C54-C55
041	Malignant neoplasm of ovary	183	C56
042	Malignant neoplasm of prostate	185	C61
043	Malignant neoplasm of testis	186	C62
044	Malignant neoplasm of bladder	188	C67
045	Malignant neoplasms of kidney and other urinary organ	189	C64-C66, C68
046	Malignant neoplasms of meninges, brain and other parts of central nervous system	191-192	C70-C72
047	Hodgkin's disease	201	C81
048	Non-Hodgkin's lymphoma	200,202	C82-C85,C96
049	Multiple myeloma and immunoproliferative neoplasms	203	C88,C90
050	Leukemia	204-208	C91-C95
051	Other cancer	163-171,181, 184, 187,190,193	REST 2 without C97
052	Malignant neoplasm of other and ill-defined sites	195	C76-C79
053	Malignant neoplasm without specification of site	199	C80
054	Malignant neoplasms of independent (primary) multiple sites	---	C97
055	In situ neoplasms, benign neoplasms and neoplasms of uncertain or unknown behaviour	210-239	D00-D48

For France, an interchange was present between the categories of Other cancer and Malignant neoplasm of other and ill-defined site prior to ICD10, and the application of the double coding coefficients seems to solve this inconsistency quite well. Malignant neoplasms without specification of site seem to be differently understood in the Czech Republic than in the two remaining countries – the deaths (compared to the population size) are by far lower. Moreover, for this cause of death an important break similar to that in France was observed after the adoption of the improved coding procedures in 2007.

Figure 41 Poorly defined cancer (items 051-054) before correction



Concerning the category of neoplasms of independent primary multiple sites, its creation brings an inherent discontinuity to cancer mortality data and in order to avoid false conclusions on decrease of other well-defined cancer, it was reconstructed a posteriori. This category encompasses a large variety of cancer sites and no simple correspondence could therefore be identified. Instead, we applied the French coefficients from the double-coding to re-create this category for years prior to its appearance in the Czech Republic and West Germany. The results of reconstructed item 054 and of application of double coding for France are shown on Figure 42.

Figure 42 Poorly defined cancer (items 051-054) after correction

ICD10 chapters III-VI

The shortlist items 056-076 contain a mixture of avoidable diseases (thyroid gland disorders, diabetes, epilepsy), public health related conditions (malnutrition, alcohol and drug abuse, meningitis), organic (senile dementia), degenerative (Alzheimer⁷⁵ and Parkinson disease) and autoimmune (multiple sclerosis) neural diseases (Table 28). Two garbage categories are included to assess the data quality and eliminate potential comparability issues – ill defined paralytic syndromes (shortlist item 072) and the above mentioned senile dementia.⁷⁶

The biggest transition problems in this group were encountered for France, namely for anemias, senile dementia, and other mental disorders in France, and were corrected by application of double-coding coefficients.

⁷⁵ In absence of the 4th digit detail, we substitute the ICD9 code for Alzheimer disease (331.0) by 331.

⁷⁶ In ICD10 the *senile dementia* (ICD9 290) was split into *vascular* (F01) and *unspecified* (F03) dementia. ICD10 thus does not contain the term “senile dementia”.

Table 28 186 shortlist, part III: ICD10 chapters III-VI

List number	Title	Category codes according to ICD9	Category codes according to ICD10
056	Thyroid gland disorders	240-246	E00-E07
057	Diabetes mellitus	250	E10-E14
058	Malnutrition	260-263	E40-E46
059	Other nutritional deficiencies	264-269	E50-E64
060	Other endocrinologic and metabolic diseases	251-259,270-279	REST 4
061	Anemias	280-285	D50-D64
062	Other blood diseases	286-289	D65-D89
063	Parkinson's disease	332	G20-G21
064	Alzheimer's disease	331*	G30
065	Alcohol abuse	291, 303	F10
066	Drug abuse	292, 304-305	F11-F19,F55
067	Multiple sclerosis	340	G35
068	Senile dementia	290	F01,F03
069	Other mental disorders	293-302, 306-319	REST 5
070	Meningitis	320-322	G00, G03
071	Epilepsy	345	G40-G41
072	Ill-defined paralytic syndromes	342,344	G81-G83
073	Inflammatory and toxic neuropathy	357	G61-G62
074	Other diseases of nervous system	323-330,333-337,341,343,346-359	REST 6
075	Diseases of the eye and adnexa	360-379	H00-H59
076	Diseases of the ear and mastoid process	380-389	H60-H95

* The Alzheimer's disease under ICD9 was distinguishable only at the 4th digit level. Using the whole category 331 however provides good approximation to Alzheimer's disease mortality.

Circulatory system diseases

The next 24 positions (077- 100) are occupied by diseases of the circulatory system. Most of the circulatory diseases share the same risk factors, and it is therefore common and correct, indeed, to broadly distinguish between coronary (ischemic) heart diseases, cerebrovascular diseases⁷⁷ and the rest. The proposed shortlist however aims to refine this “classical” distinction with respect to the clinical course (acuity/chronicity), diverse etiology (infectious / degenerative / induced by functional impairment; distinction between hemorrhagic and vascular stroke), and diagnostic specificity (inclusion of garbage codes).

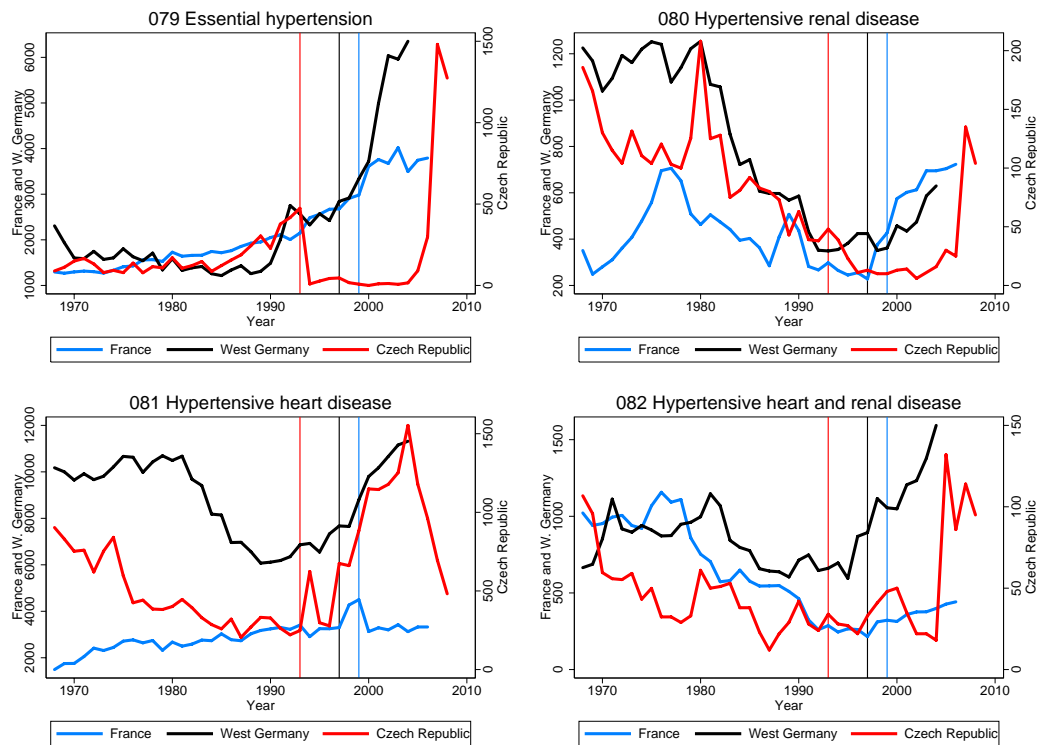
The nomenclature of cardiovascular diseases, more than for other groups of causes, varies over time and over countries. This became apparent already during the transitions between ICD8 and ICD9 (see Chapter IV), when national coding habits resulted in diverse correspondences in elementary associations. The ICD9/ICD10 correspondences given in Table 29 are derived from the existing shortlists and checked for validity on the underachieved reconstruction data for West Germany.

⁷⁷ Nevertheless, it is also common (and incorrect) to include the ICD9 item 435 *Transient cerebral ischemia* into cerebrovascular diseases as defined by ICD10 (I60-I69). This code has been moved to the chapter Diseases of nervous system.

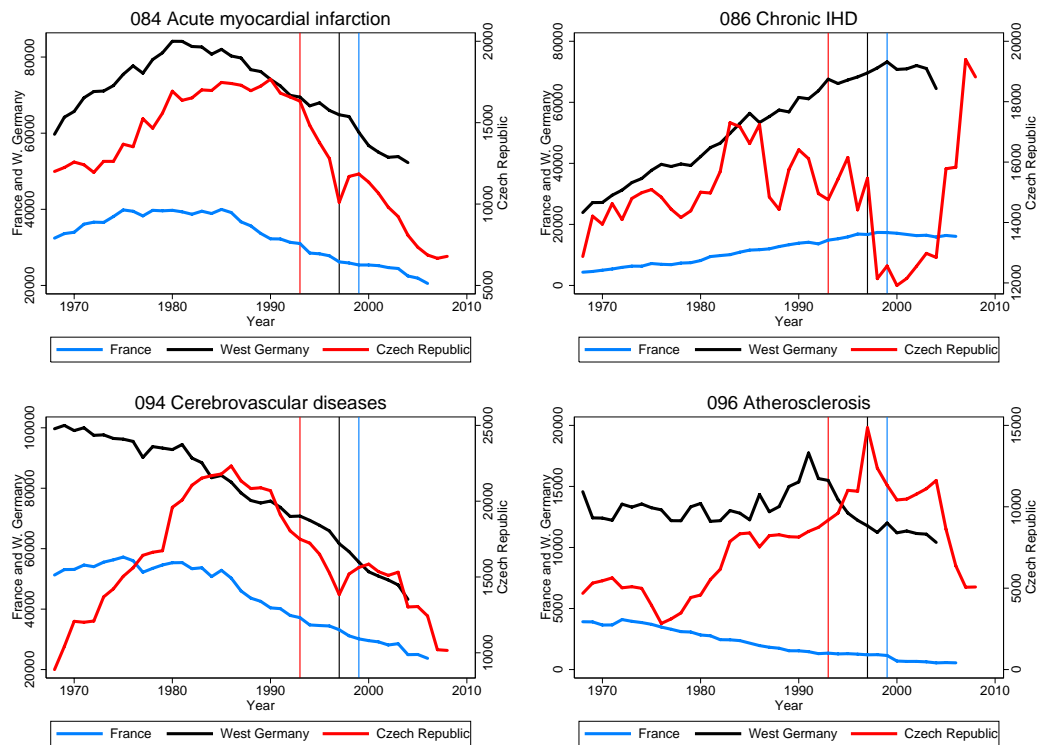
Table 29 186-shortlist, part IV: circulatory diseases

List number	Title	Category codes according to ICD9	Category codes according to ICD10
077	Acute rheumatic heart fever	390-392	I00-I02
078	Chronic rheumatic heart diseases	393-398	I05-I09
079	Essential hypertension	401	I10
080	Hypertensive renal disease	403	I12
081	Hypertensive heart disease	402	I11
082	Hypertensive heart and renal disease	404	I13
083	Secondary hypertension	405	I15
084	Acute myocardial infarction	410	I21-I22
085	Other acute IHD	411	I24
086	Chronic IHD	412-414	I20,I25
087	Acute and subacute endocarditis	421	I33
088	Diseases of pericardium and acute myocarditis	420,422-423	I30-I31,I40
089	Other diseases of endocardium	424	I34-I38
090	Heart failure	428	I50
091	Cardiomyopathy	425	I42
092	Other heart disease	415-417,426-427,429	I26-I28,I44-I49, I51
093	Hemorrhagic stroke	430-432	I60-I62
094	Cerebrovascular diseases	433-434,436-438	I63-I69
095	Transient cerebral ischemia	435	G45
096	Atherosclerosis	440	I70
097	Aortic aneurysm	441	I71
098	Other diseases of arteries, arterioles and capillaries	442-448	I72-I78
099	Embolism, thrombosis and phlebitis of veins	451-453	I80-I82
100	Other circulatory diseases	454-459	I83-I99, I15

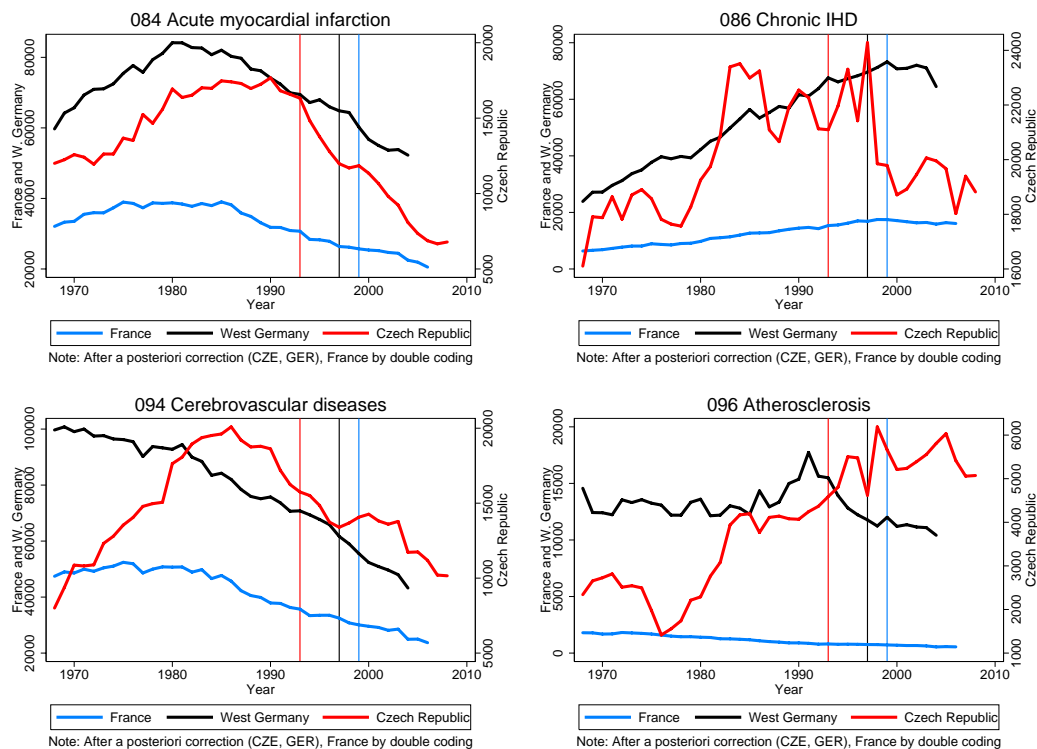
The change in coding practices adopted in the Czech Republic between 2006 and 2007 becomes fully apparent in the trends of deaths counts from diverse categories of hypertension. Figure 43: essential hypertension and hypertensive renal disease gained with ICD10 significant number of death counts in all the three countries, while other manifestations of hypertension decreased or increased inconsistently. As for essential hypertension, the increase was observed for all the three countries and may thus relate to the adoption of ICD10. For the remaining hypertensive diseases, the inconsistencies are observed only in the Czech Republic.

Figure 43 Chaotic trends for hypertension (items 079-082)

Let us now check the group of the most frequent cardiovascular diseases – myocardial infarction, chronic ischemic heart disease, cerebrovascular diseases and atherosclerosis. While the mortality from myocardial infarction and cerebrovascular diseases seem as stable medical entities in all the three countries, for the Czech Republic the results for chronic ischemic heart disease and, especially, for atherosclerosis are quite chaotic. First of all, the deaths from chronic ischemic heart disease went through dramatic decline and increase within the last decade. Exceptionally high in the Czech Republic are also the numbers of deaths coded to atherosclerosis – their proportion in all deaths in 1997 was more than 13%, compared to France and West Germany, where the share moved around less than 0.5 or 2 %, respectively. In 2007, an important part of the atherosclerosis excessive coding was removed by the cause-of-death statistics improvement project – resulting in a drop to 4.8 % in 2007. Regarding the chronic ischemic heart disease, as Štyglerová (2008) claims, it was strongly underestimated due to preference of atherosclerosis or cerebrovascular condition if both were listed on the death certificate. This statement finds support in our data - the sudden rise of deaths from ischemic heart disease was compensated by concurrent decrease in both cerebrovascular diseases and atherosclerosis. Moreover, another break occurred in 1997, when a temporary increase of atherosclerosis coincided with drop in deaths from acute myocardial infarction and cerebrovascular diseases.

Figure 44 The most frequent cardiovascular diseases (items 084,086,094,096) before correction

The observed tendencies and the information contained in the article by Štyglarová (2008) were used to estimate corrections a posteriori for these four diseases in the Czech Republic, with results displayed on Figure 45.

Figure 45 The most frequent cardiovascular diseases (items 084,086,094,096) after correction

The figures show the elimination of break in 1997 for items 084 and 094, and visible improvement of comparability of ischemic heart disease mortality in the Czech Republic adding 50% of deaths from atherosclerosis and 10% of deaths from cerebrovascular diseases prior to 2006. The applied proportions are approximative and so far based on short series of data. For definitive reclassification, the results from the comparative study of coding before and after implementation of the quality improvement programme in the Czech Republic will be needed.

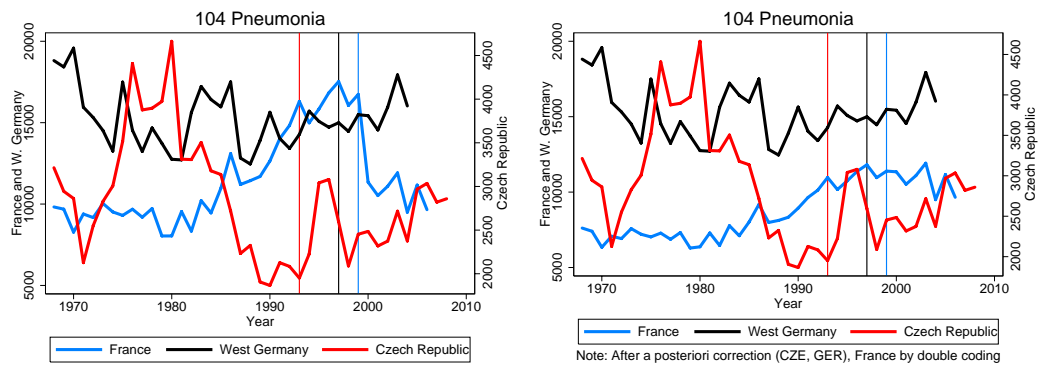
Respiratory diseases

The shortlist items 101-115 are reserved for respiratory diseases. It allows to distinct infectious, occupational or chronic respiratory diseases.

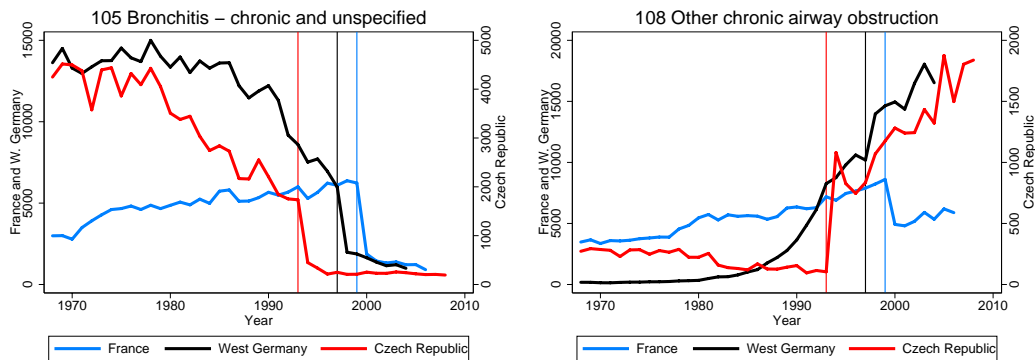
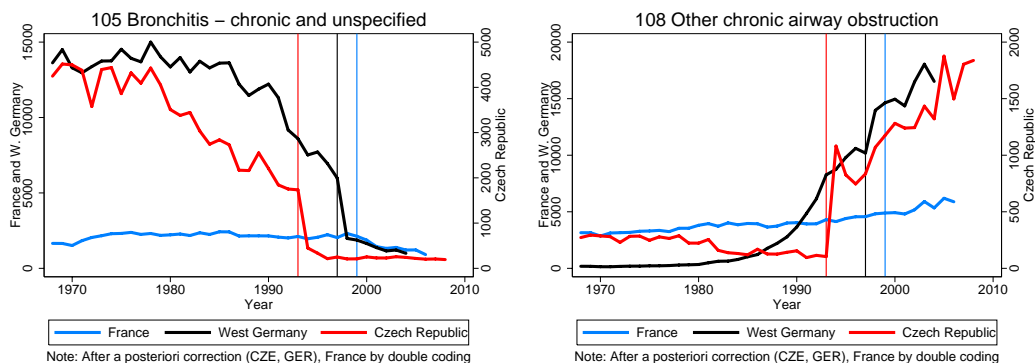
Table 30 186-shortlist, part V: respiratory diseases

List number	Title	Category codes according to ICD9	Category codes according to ICD10
101	Acute respiratory infections	460-465	J00-J06, J22
102	Acute bronchitis and bronchiolitis	466	J20-J21
103	Influenza	487	J09-J11
104	Pneumonia	480-486	J12-J18
105	Bronchitis, chronic and unspecified	490-491	J40-J42
106	Emphysema	492	J43
107	Asthma	493	J45-J46
108	Other chronic airway obstruction	496	J44
109	Bronchiectasis	494	J47
110	Pneumoconioses and chemical effects	500-506	J60-J66, J68
111	Pneumonitis due to solids and liquids	507	J69
112	Empyema	510	J86
113	Pleurisy	511	J90, J92, J94
114	Other interstitial respiratory diseases	514-518	J80-J84
115	Other respiratory diseases	470-478, 495, 508, 512-513, 519	J30-J39, J67,

According to the results of the bridge coding studies, we expected a dramatic drop in pneumonias in ICD10 due to change in coding Rule 3. However, major problem with pneumonia coding was only observed in France (Figure 46) and rectified by application of double coding coefficients. In France, transition-related problems were observed for several other respiratory conditions (see light grey areas in Table 30).

Figure 46 Pneumonia under ICD10

In all the three countries, problems occurred with chronic and unspecified bronchitis and chronic airway obstruction. Although the NCHS 113 list gives the same correspondence as we used, it is not applicable at the 3-digit ICD level, while in both Czech Republic and West Germany, the chronic airway obstruction comprised an important part of chronic and unspecified bronchitis of ICD9 (Figure 47, Figure 48). For further analyses, these conditions will therefore be grouped.

Figure 47 Problematic respiratory diseases (items 104,105,106)**Figure 48 Effect of double-coding coefficients on problematic respiratory diseases**

Other well-defined diseases

The shortlist items 116-150 cover the rest of well-defined diseases – digestive diseases, diseases of skin, musculoskeletal diseases, genitourinary diseases, and diseases related to pregnancy and childbirth. The transition for these causes under the given correspondences went mostly well. It should be noted that according to the changes in the ICD10 chapter, the

musculoskeletal diseases of ICD10 contain also gout (ICD9 274) and polyarteritis nodosa and allied conditions (446).

Table 31 186-list, part VI: digestive, skin, musculoskeletal and genitourinary diseases

List number	Title	Category codes according to ICD9	Category codes according to ICD10
116	Gastric and duodenal ulcer	531-533	K25-K27
117	Gastrojejunal ulcer	534	K28
118	Gastritis and duodenitis	535	K29
119	Diseases of appendix	540-543	K35-K38
120	Hernia	550-553	K40-K46
121	Enteritis, colitis and other intestinal diseases	555-566,569	K50-K63
122	Chronic liver disease and cirrhosis	571	K70,K73-K74
123	Cholelithiasis and other disorders of gallbladder	574-575	K80-K82
124	Other digestive diseases	530,536-537,567-568,570,572-573,576-579	REST 11
125	Diseases of skin and subcutaneous tissue	680-709	L00-L99
126	Rheumatoid arthritis and osteoarthritis	714-715	M05-M06,M15-M19
127	Other musculoskeletal diseases	710-713,716-739, 274, 446	REST 13
128	Acute and rapidly progressive nephritic and nephrotic syndrome	580-581	N00-N01,N04
129	Other nephritis and nephropathy	582-583,587	N02-N03,N05-N07,N14,N26
130	Renal failure	584-586	N17-N19
131	Other disorders of kidney	588-589	N25,N27
132	Infections of kidney	590	N10-N12,N15
133	Urolithiasis	592,594	N20-N23
134	Other diseases of kidney and ureter	591,593	N06,N13,N28
135	Other diseases of urinary tract	595-599	N02,N30-N36,N39
136	Hyperplasia of prostate	600	N40
137	Inflammatory diseases of female pelvic organs	614-616	N70-N77
138	Other diseases of genital organs	601-611,617-629	N41-N64, N80-N99

Specific certification habits were found in France for renal failure. By both methods, the share of deaths attributed to renal failure in France was substantially higher since the beginning of ICD9, while in other two countries the number of deaths from renal failure progressively increased only recently (Figure 49). Moreover, other genitourinary causes (infections of kidney, nephritic and nephritic syndrome, and other diseases of kidney) were consistently lower in France than in the two other countries, and even the application of the double coding coefficients did not solve this incomparability and made it even more visible lowering the death counts from nephritic and nephritic syndromes (Figure 50). This case also point at one disadvantage of the use of double coding performed only on the data from one last year of the previous classification: if the mortality from one cause had decreased prior to the double coding,

the double coding will attribute false small proportions, resulting in artificial lowering this cause in the past. Due to these issues, we suggest that in further analyses these categories be used grouped.

Figure 49 Diverse coding of renal diseases (items 129, 130, 132, 134)

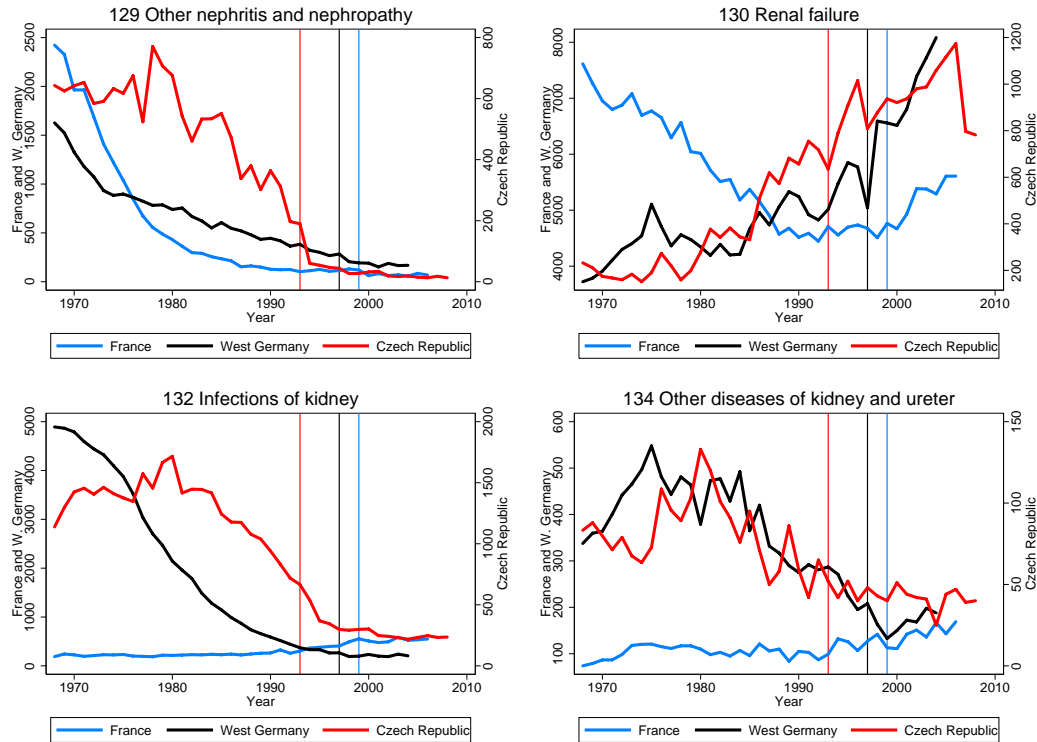
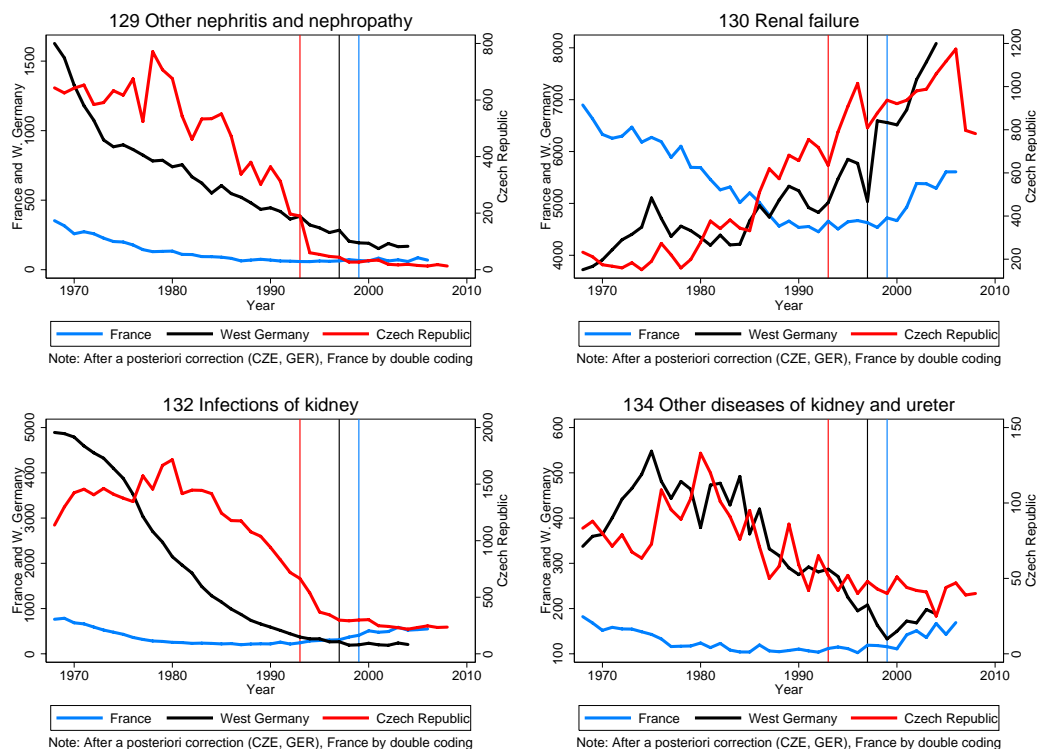


Figure 50 Diverse coding of renal diseases (items 129, 130, 132, 134) accentuated by double-coding coefficients



Pregnancy, childbirth, perinatal and congenital causes of death

The deaths related to childbirth are very low and decreasing in numbers, but they also serve as a sensitive indicator of the health care quality. We decided to keep 12 categories of maternal, perinatal and congenital mortality. In majority, the transition result was satisfactory.

Table 32 186-shortlist, part VII: pregnancy, childbirth, perinatal and congenital conditions

List number	Title	Category codes according to ICD9	Category codes according to ICD10
139	Pregnancy with abortive outcome	630-639	O00-O07
140	Other complications of pregnancy, childbirth and puerperium	640-676	O10-O99
141	Birth injury and neonatal haemorrhagia	763,767,772	P03, P10-P15, P50-P52, P54
142	Short gestation/low birthweight	765	P07
143	Intrauterine hypoxia and birth asphyxia	768	P20-P21
144	Respiratory distress syndrome	769	P22
145	Other respiratory disease of newborn	770	P23-P28
146	Infections specific to the perinatal period	771	P35-P39
147	Other conditions originating in the perinatal period	760-762,764,766,773-779	P00-P05,P08-P21,P29,P53,P55-P96
148	Congenital malformations of nervous system	740-742	Q00-Q07
149	Congenital malformations of heart	745-747	Q20-Q28
150	Other congenital malformations, deformations, and chromosomal abnormalities	743-744,748-759	Q10-Q18,Q30-Q99

Ill-defined causes of death

Finally, we keep five positions for ill-defined causes grouped into SIDS, symptoms and signs, senility, sudden death and unknown causes.

Table 33 186-shortlist, part VIII: Ill-defined causes of death

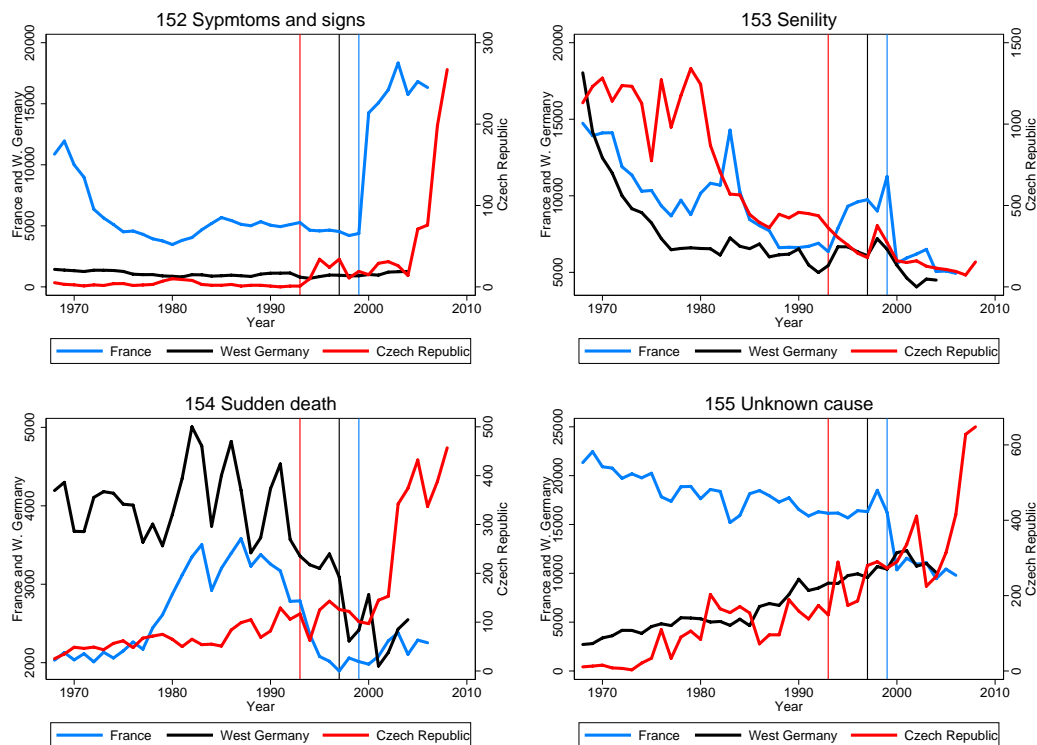
List number	Title	Category codes according to ICD9	Category codes according to ICD10
151	Sudden infant death syndrome (SIDS)	798.0	R95
152	Symptoms and signs	780-796	R00-R94
153	Senility	797	R54
154	Sudden death	798	R96,R98
155	Unknown cause	799	R99

In the absence of the 4th ICD9 digit, The SIDS was reconstructed as all deaths at age 0 from Sudden death, cause unknown of ICD9.

ICD10 brought increased codification into the category of symptoms and signs, observed especially in the year 2000 in France. In 2007 in the Czech Republic an important increase of the proportion of ill-defined causes was observed: the proportions suddenly passed from historically stable low levels (0.5%) to almost 1.5% in 2008. At the same time, by the last

available year of data, West Germany maintained 2.8% and France 6.5% of ill-defined causes of death.

Figure 51 Ill-defined causes of death under ICD10



The application of the double coding coefficients in France levelled-off the observed increased in mortality from symptoms and signs and decreased the levels of senility under ICD9, but at the same time created a break for unknown cause. As in the previous reconstruction (see section 4.3), we eliminate the influence of divergent levels of ill-defined causes by their proportional redistribution into well-defined causes of death and accidents.

External causes of death

Classification of external causes of death and especially of accidents has undergone one of the biggest innovations with ICD10. First, the classification logic of transport accidents completely changed – accidents are no more classified by the transport means (car, bus, train etc.), but by the nature of injured person – car occupant, pedal cyclist, pedestrian. On the 3-digit level we therefore have no clue how to redistribute the deaths between the two successive classifications. The 4th digit would possibly bring some clarification, but as ICD Translator gives for some transport accidents up to 58 correspondences (ex. Other motor vehicle nontraffic accident involving collision with moving object, unspecified person E822.9), the result would always be approximative.

Table 34 186-shortlist, part IX: External causes of death

List number	Title	Category codes according to ICD9	Category codes according to ICD10
156	Motor accident	E810-E825	V02-V04,V09,V12-V14,V20-V79
157	Land transport accidents	E800-E809,E826-E829,E846	V01,V05-V08,V10-V11,V15-V19,V80-V89
158	Water, air, space and other and unspecified transport accidents	E830-E845, E847-E848	V90-V99
159	Accidental falls	E880-E888	W00-W19
160	Accidental discharge of firearms	E922	W32-W34
161	Accidental drowning and submersion	E910	W65-W74
162	Accidental exposure to smoke, fire and flames	E890-E899	X00-X09
163	Accidental poisoning by alcohol	E860	X45
164	Accidental poisoning by other substance	E850-E869	X40-X44,X46-X49
165	Inhalation and ingestion	E911, E912	W78-W80
166	Mechanical suffocation	E913	W75-W77,W81,W83-W84
167	Occupational and machine injuries	E919,E920	W24-W31,W45,X17
168	Suicide and self-inflicted poisoning by ingestion and inhalation	E950-E952	X60-X69
169	Suicide and self-inflicted injury by hanging, strangulation, and suffocation	E953	X70
170	Suicide and self-inflicted injury by submersion [drowning]	E954	X71
171	Suicide and self-inflicted injury by firearms, air guns and explosives	E955	X72-X75
172	Suicide and self-inflicted injury by other and unspecified means	E956-E958	X76-X84
173	Fight, brawl, rape	E960	Y04-Y05
174	Assault by firearms and explosives	E965	X93-X96
175	Assault by cutting and piercing instrument	E966	X99
176	Assault by other and unspecified means	E968	X97-X98,Y01-Y03,Y06-Y09
177	Other assault	E961-E964,E967	X85-X92,Y07
178	Ingestion and inhalation of undetermined intent	E980-E982	Y10-Y19
179	Submersion [drowning] of undetermined intent	E984	Y21
180	Injury by firearms, air guns and explosives of undetermined intent	E985	Y22-Y25
181	Fall of undetermined intent	E987	Y30
182	Other event of undetermined intent	E983,E986,E988	Y20,Y28, Y34
183	Treatable complications of medical and surgical care	E870-E879	Y60-Y69,Y83-Y84
184	Other complications of medical and surgical care	E930-E949	Y40-Y59
185	Operations of war	E990-E999	Y36
186	Other accidents and late effects of accidents	REST	REST 20

First of all, due to the innovation described above, at this level of analysis it makes little sense to separate the first two categories (motor accidents and land transport accidents) (Figure

52). The figures demonstrate that when applying the shortlist correspondences the breaks were similar in all the three countries, while the application of double-coding coefficients for France corrected the problem of transition (Figure 53). The problem of definition however remained and these accidents will be grouped.

Figure 52 Traffic accidents

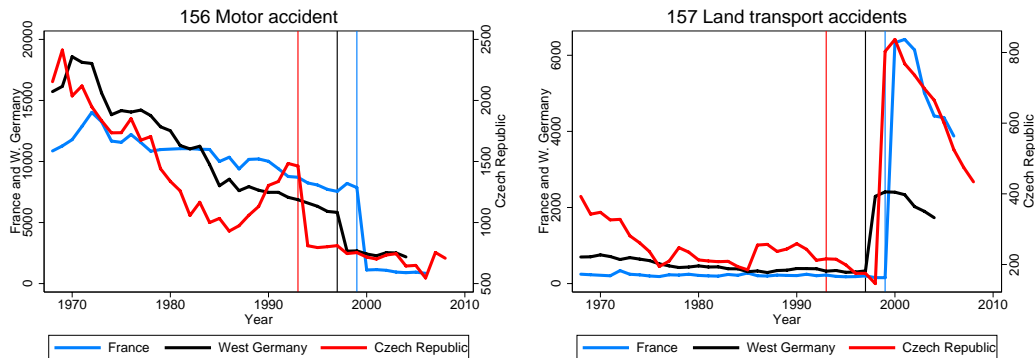
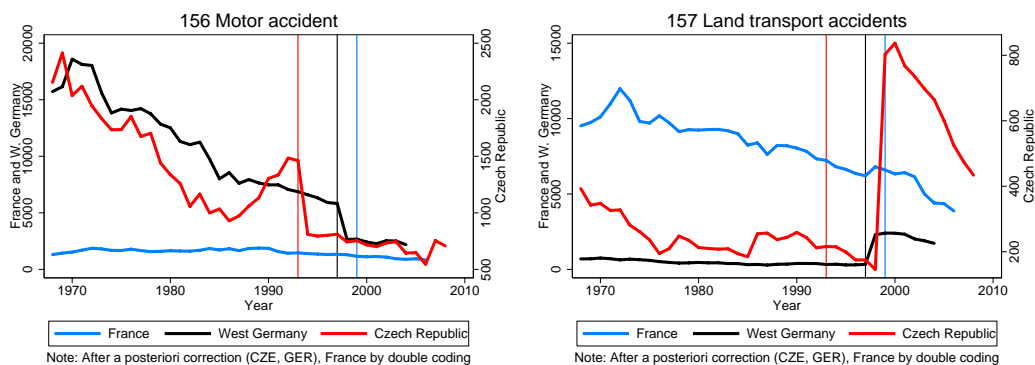
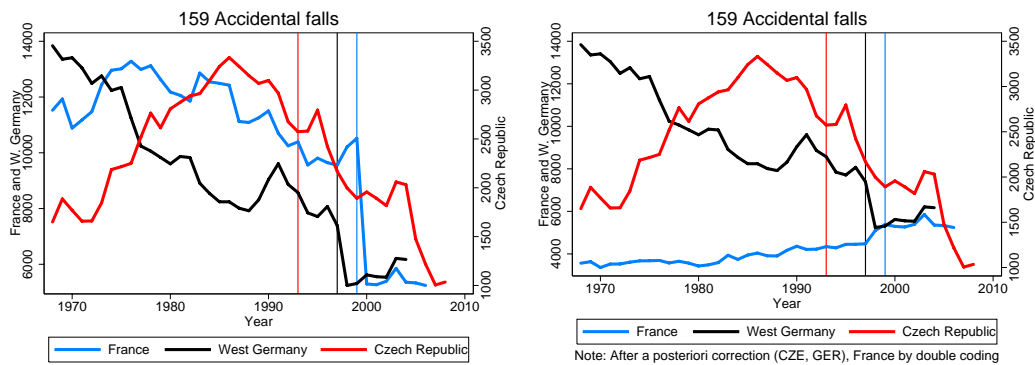
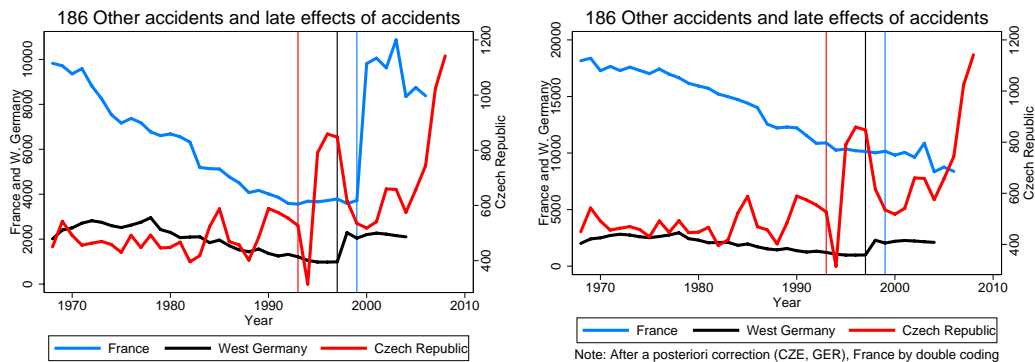


Figure 53 Traffic accidents: results of application of double coding coefficients



Accidental falls are another problematic category. In all the three countries, using the correspondences given by the 186-shortlist, a dramatic drop in death counts from accidental falls was observed, accompanied at the same time by an increase in the remaining category of external causes (shortlist item 186). Again, in the Czech Republic this change came into effect only after 2006, which brings another support to the hypothesis that the ICD10 coding rules have substantially changed the definition of accidental falls. Using the double-coding coefficients rectified the series in France, but due to potential problems, until a more focused study, accidental falls and the rest of external causes should be grouped as well.

Figure 54 *Accidental falls before and after application of double coding coefficients***Figure 55** *Other accident and late effects of accidents before and after application of double coding coefficients*

Among all the chapters of ICD10, the one of accidental mortality shows the most of transition problems. Not shown here were also, for example, dramatic drops in accidents of undetermined intent or complications of medical and surgical care, which would require a much deeper study.

Summary of the corrections a posteriori

As we mentioned several times in this chapter, some of the shortlist items required further corrections. These were applied only in the Czech Republic and West Germany. Table 35 summarizes these corrections by country and year.

The correction applied to Multiple malignant neoplasm of independent primary multiple sites was common to both countries and differed only by the application time range: in West Germany the correction coincided with the duration of ICD8 and ICD9, while in the Czech Republic the correction was extended up to the year 2006, where new coding rules came into effect.

Another correction common to both countries was that of SIDS, which was extracted as deaths at age 0 from the reconstructed ICD9 item sudden death.

For West Germany only, we have corrected the false coding of chronic viral hepatitis for the period prior to ICD10. The corrections of cardiovascular mortality, based on the most recent data, were applied only at the Czech data.

Table 35 Summary of a posteriori corrections for abridged reconstruction

Time range for:		Source item:	Target item:	Proportions (%)					
Czech Republic	West Germany			1968-1993	1994-1996	1997	1998-2004	2005	2006
1968-2006	1968-1997	026	054	6.11	6.11	6.11	6.11	6.11	6.11
1968-2006	1968-1997	027	054	5.46	5.46	5.46	5.46	5.46	5.46
1968-2006	1968-1997	028	054	1.07	1.07	1.07	1.07	1.07	1.07
1968-2006	1968-1997	029	054	1.50	1.50	1.50	1.50	1.50	1.50
1968-2006	1968-1997	030	054	2.00	2.00	2.00	2.00	2.00	2.00
1968-2006	1968-1997	031	054	0.27	0.27	0.27	0.27	0.27	0.27
1968-2006	1968-1997	032	054	0.43	0.43	0.43	0.43	0.43	0.43
1968-2006	1968-1997	033	054	1.01	1.01	1.01	1.01	1.01	1.01
1968-2006	1968-1997	034	054	5.96	5.96	5.96	5.96	5.96	5.96
1968-2006	1968-1997	035	054	1.59	1.59	1.59	1.59	1.59	1.59
1968-2006	1968-1997	036	054	0.76	0.76	0.76	0.76	0.76	0.76
1968-2006	1968-1997	037	054	4.88	4.88	4.88	4.88	4.88	4.88
1968-2006	1968-1997	038	054	2.02	2.02	2.02	2.02	2.02	2.02
1968-2006	1968-1997	040	054	2.04	2.04	2.04	2.04	2.04	2.04
1968-2006	1968-1997	041	054	2.87	2.87	2.87	2.87	2.87	2.87
1968-2006	1968-1997	042	054	3.14	3.14	3.14	3.14	3.14	3.14
1968-2006	1968-1997	044	054	5.47	5.47	5.47	5.47	5.47	5.47
1968-2006	1968-1997	045	054	2.80	2.80	2.80	2.80	2.80	2.80
1968-2006	1968-1997	048	054	0.44	0.44	0.44	0.44	0.44	0.44
1968-2006	1968-1997	049	054	0.44	0.44	0.44	0.44	0.44	0.44
1968-2006	1968-1997	050	054	0.83	0.83	0.83	0.83	0.83	0.83
1968-2006	1968-1997	051	054	3.84	3.84	3.84	3.84	3.84	3.84
1968-2006	1968-1997	055	054	0.40	0.40	0.40	0.40	0.40	0.40
1997		096	084			12.60			
1997		096	094			6.30			
1968-2006		096	086	50.00	50.00	50.00	50.00	30.00	15.00
1968-2006		094	086	10.00	10.00	10.00	10.00	10.00	10.00
	1968-1997	122	020	4.00	4.00	4.00			
1968-1993	1968-1997	154*	151	100.00	100.00	100.00			

* only for age 0

Chapter V.

International comparability of the reconstructed time series

In the introduction to the 2001 final report on Comparability and Quality Improvement of European Causes of Death Statistics⁷⁸, on page 5, it reads: „*The analysis of European mortality rates outlines important differences for various causes of death, but before attempting to interpret these inter-country differences in terms of etiological factors, it is essential to assess the possible biases affecting the comparability of the data.*“ Let these words introduce this chapter.

There is very little discussion about the existence of comparability issues in the cause-of-death statistics. In contrary, determining the magnitude of the bias is problematic. Too many factors influence what will appear in the statistics – the certifier's person, his professional training, the country's cultural background, the death certificate format and its transmission as well as the level of confidentiality of medical information contained in it. Last, but not least, the coding process itself and selection of underlying cause play a role.

Since 1994, the problem of the comparability of public health statistics between European Union countries has been addressed by EUROSTAT.⁷⁹ A study on certification and coding practices was conducted based on a questionnaire sent to representatives of 20 countries/regions of the EU during 1999-2001. The results of the study were accompanied by exhaustive bibliographic search and summary of major findings. The survey revealed disparities in almost every aspect of certification and coding across Europe.

The report also confirmed that specific causes of death are influenced by certification or coding practices more than the others. These include, typically, social pathologies (suicides,

⁷⁸ Jouglé E, Rossollin F, Niyonsenga A, Chappert JL, Johansson LA, Pavillon G (2001) Comparability and quality improvement in European causes of death statistics. Eurostat, Project 96 / S 99-5761 / EN. : 190p.
http://europa.eu.int/comm/health/ph/programmes/monitor/fp_monitoring_1998_frep_04_en.pdf

⁷⁹ The investigations are located within the larger context of a Working Group on "Public Health Statistics", organised by EUROSTAT, and based on the Statistical Framework Program of the European Commission.

drug and alcohol abuse, violence), stigmatizing conditions (HIV), mental diseases and the ill-defined causes of death.

This chapter will examine the comparability of the reconstructed time series in the three countries with the aim to compile a reasonably-sized analytical list, which would both capture the sources of international cause-specific mortality, and at the same time would be as free as possible from known comparability issues. This list would further serve as analytical entry for the following chapters.

6.1 Capturing information from the detailed time series

The comparability was evaluated via age-standardized death rates (SDR) by ICD10 chapter, country and sex. The SDRs for each cause i from the 186-shortlist were computed using the following equations, where x stands for age group (0-85+), M for mortality rate, D for the observed death counts, P for the exposure (person-years lived throughout the given age interval), and P^{st} for the age structure of the WHO European standard population (sized 1,000,000 in total for better convenience). For the Czech Republic and West Germany the exposures were taken from the HMD, for France we used populations adapted to the particular age format of the French cause-of-death data (described earlier in chapter III).

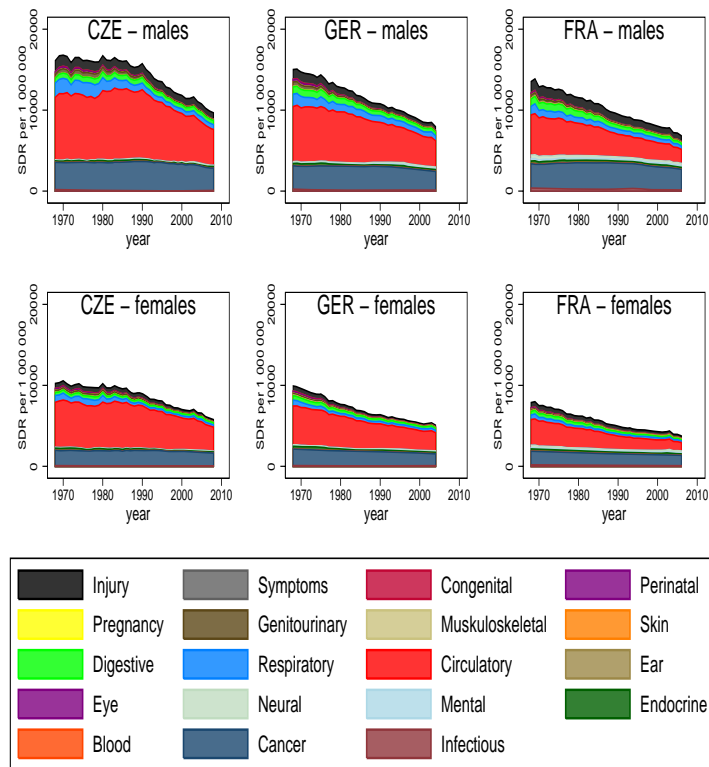
$$M_x^i = \frac{D_x^i}{P_x}$$

$$SDR^i = \sum_x M_x^i \cdot \left(\frac{P_x^{st}}{\sum_x P_x^{st}} \right)$$

The results have been plotted separately by ICD chapter, country and sex on unique y-axis scale using stacked area plots sorted by the 186-shortlist order. The chapter of ill-defined causes of death was proportionally redistributed among well-defined diseases and accidents, and will therefore not be shown. We are also not showing chapters with mortality levels close to 0 (diseases of eye, ear, and skin).

The first figure (Figure 56) shows the SDRs for the main ICD10 chapters. Both mortality differences and movement depend mainly on the level of circulatory mortality, while mortality from cancer tends to stable level over time and over countries. Important decreases were also seen for respiratory and digestive mortality.

Figure 56 SDR by main ICD chapters



Infectious and parasitic diseases

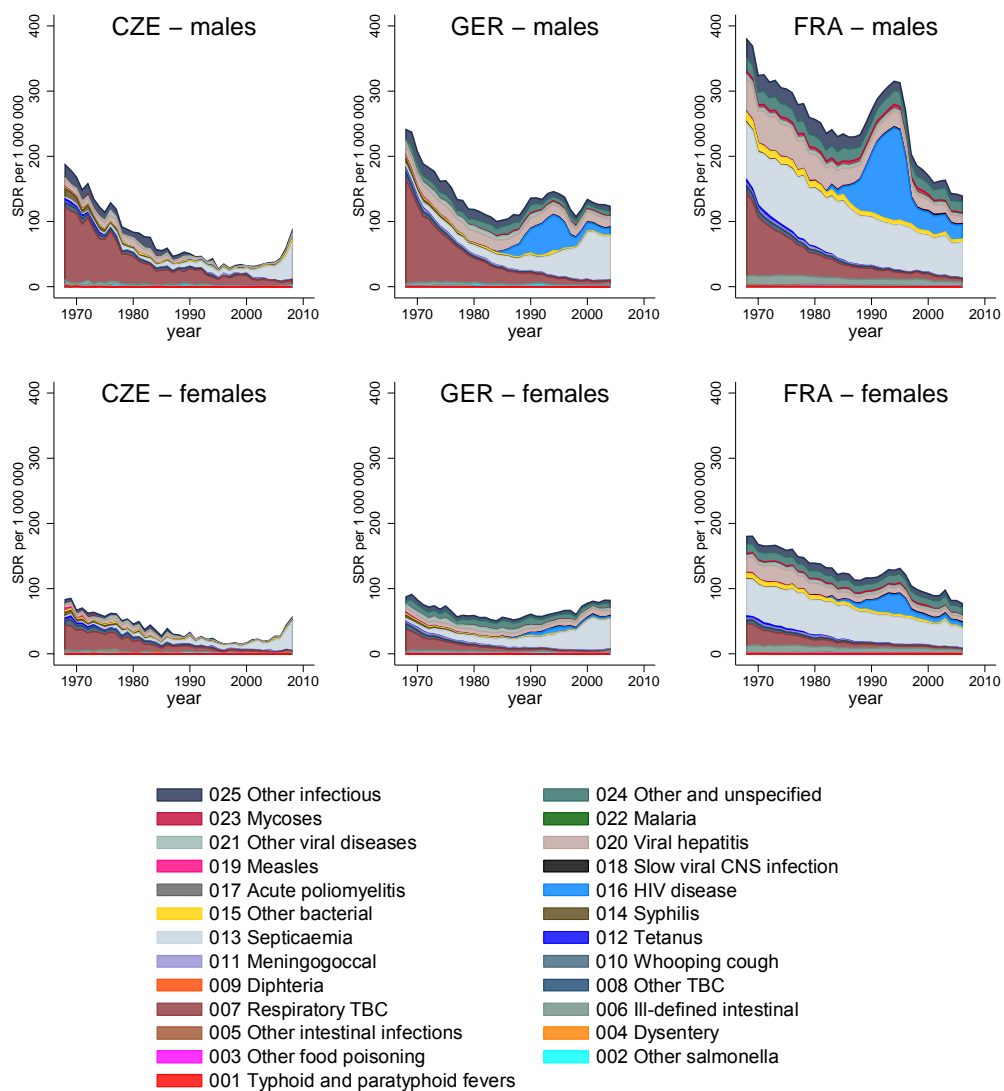
During the 20th century the share of infectious diseases on the total mortality substantially decreased: according to Srb and Haas (Srb and Haas 1956), the mortality from infectious diseases dropped by 75 % between 1920-1924 and 1950-1954 in Czech Republic. Similarly, in France, Vallin and Meslé speak about „*baisse avant la dernière guerre*“, but about „*effondrement des maladies infectieuses*“ after 1950 (Vallin, Meslé et al, 1988: p. 156). Many infectious diseases (typhoid and paratyphoid fever, diphtheria, dysentery, tuberculosis) began to withdraw already before the WWII due to sanitation progress, vaccination, and discovery of sulphonamide drugs. Antibiotics then represented the next milestone of mortality from bacterial infections.

While the „old“ infections are on the verge to extinction, new ones emerge. Emerging diseases are defined by CDC as „*diseases of infectious origin whose incidence in humans has increased within the past two decades or threatens to increase in the near future*“. Typical examples of emerging (or re-emerging) diseases include AIDS, diseases due to drug-resistant pathogens, vector-borne or zoonotic diseases, foodborne and waterborne illnesses, diseases in special settings (such as child care facilities), or vaccine-preventable diseases (measles, polio, pertussis, and diphtheria in undiminished populations). In developed countries nowadays, infectious diseases are at historically minimum levels, but still remain under strict epidemiological surveillance.

Figure 57 shows, that with respect to the infectious mortality, France ranks the highest among the three countries, for both sexes. The sex-specific gradient of infectious mortality is similar in all the three countries of interest.

Prior to the mid-1980's, the overall movement of the chapter of infectious diseases was dominated by the general decrease of tuberculosis (TBC) and other bacterial mortality. In the mid-1980s, the AIDS epidemic hit the infectious mortality hard especially in the French males, and to a lesser extent in West German males, while the Czech Republic has never experienced a dramatic AIDS mortality increase.

Figure 57 Chapter 1 Certain infectious and parasitic diseases



The reconstructed series also show that important part is taken by the two causes previously listed as potentially problematic - septicaemia and viral hepatitis. The use of double-coding coefficients in France resulted in an important increase of the septicaemia SDR for the whole chapter of infectious diseases during the whole period of ICD9, while in the two remaining countries the increase came only later and gradually after the adoption of ICD10 coding rules. By the end of the period of observation, the sex-specific septicaemia mortality however was of

similar importance in all the three countries. This comparability issue prior to ICD10 for septicaemia can hardly be removed at this stage of the work. It is also questionable whether the trend resulting from the French double coding is fully realistic.

The reconstructed trends for viral hepatitis show that after the correction, the male hepatitis mortality is comparable in France and West Germany, and much lower in the Czech Republic.

There also seems to be a direct relation between the total level of infectious mortality and the share of other and unspecified infectious diseases, suggesting that these categories gather similar content consisting of a mixture of rare, unspecific or ill-defined infections.

For further analysis, we extract four categories of infectious mortality, comprising of:

- **Bacterial infection (items 001-002,014-015)** as decisive factor in infectious mortality decrease prior to the 1980s;
- **Septicaemia (item 013)** as a new aspect of infectious mortality introduced by the adoption of ICD10;
- **AIDS (item 016)** as such, and
- **Viral hepatitis (item 020)** which is assumed to cause up to 80% of liver cancer.⁸⁰

The remaining infections will be added to the category of “Other diseases”.

Malignant neoplasms

Compared to the infectious diseases, the graphs’ y-scale for the chapter of malignant neoplasms is 10fold and the order of countries by the mortality level changes as well (Figure 58). The sex structure of cancer mortality also reflects the sex-specificity of some cancer localisations.

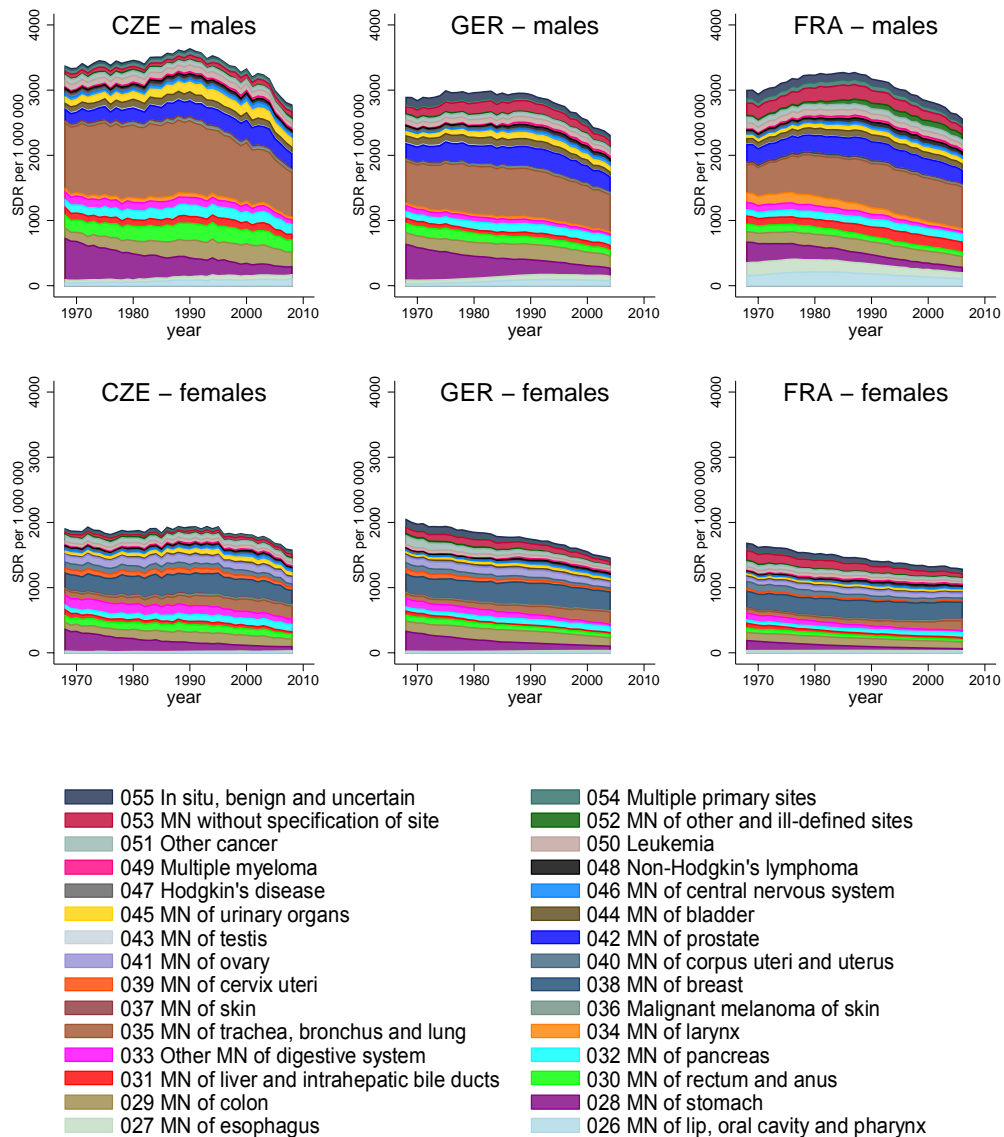
Male cancer mortality was the highest in the Czech Republic and the lowest in West Germany. If individual cancer site is considered, the male cancer mortality in all the three countries is clearly dominated by cancer of lung, cancer of prostate, cancer of colon and rectum and initially also the cancer of stomach. In France, lower lung cancer SDR goes hand in hand with higher mortality from cancer of lip, oral cavity, pharynx, esophagus and larynx. All of these cancer types started to decline in France as from the beginning of the 1980s, while in the Czech Republic and West Germany only a decade later. For the whole period, the Czech males held the first position in mortality from cancer of colon, rectum and anus.

In French females, the cancer mortality was the lowest among the three countries in 1968 and decreased to the lowest level in 2006. The Czech and German females has similar cancer mortality level at the beginning, but the trends diverged later on mainly due to cancer of colon, rectum and anus, other digestive cancer, and increase of lung cancer mortality in Czech females. Same as for males, a universal decline of stomach cancer was observed.

Regarding the specificity, France and West Germany experience higher attribution to other and poorly defined cancer categories for both sexes (items 051-055).

⁸⁰ <http://www.cdc.org/hepatitis>

Figure 58 Chapter 2 Neoplasms



A detailed analysis of cancer mortality by site can surely provide interesting results regarding for example the concrete risk factors, the level of prevention and treatment etc. Nevertheless, keeping in mind that we want our analytic list to be reasonable in size, we select six groups of cancer. These are:

- **smoking related cancer (items 026-027, 034-035)** as malignant neoplasms with the highest reported relative risk for smokers.⁸¹ The relative risks as given by the CDC for current male smokers are: cancer of lung 23.3%, cancer of larynx 14.6%, cancer of lip, oral cavity and pharynx 10.9% and cancer of esophagus 6.8%⁸²;
- **stomach cancer (item 028)** as a factor of continuous cancer mortality decline;
- **colorectal cancer (items 029-030)** as a major life-style related health threat;

⁸¹ The *relative risk (RR)* is the risk of death from cancer among current or former smokers when compared with the risk for non-smokers. (<http://www.cdc.org>)

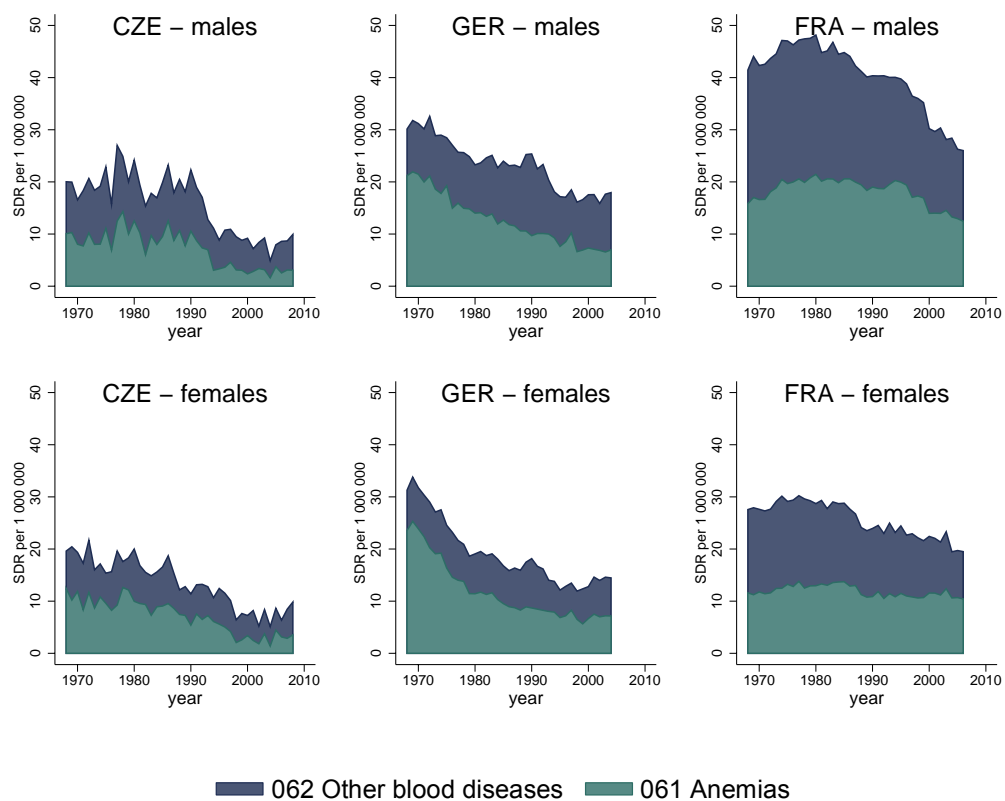
⁸² The other cancer sites have relative risks lower than 3%.

- **breast cancer (item 038)** as the most important cancer localization in females;
- **prostate cancer (item 042)** as a stable and important part of male cancer profile, and
- **other cancer** to distinguish the tumoral process from the rest of diseases. This category is heterogeneous both in the etiology and the localization, and taken as a whole, it also occupies a stable part of cancer mortality without any reported comparability issues.

Diseases of blood and immune system disorders

The third ICD10 chapter consists in a large part of anemias with comparable levels of mortality across the three countries, and of other blood diseases, double in size in French males and females (Figure 59). This category is however very low in death counts and will not figure separately in our analytical list.

Figure 59 Chapter 3 Diseases of the blood and blood-forming organs and certain disorders involving the immune mechanism



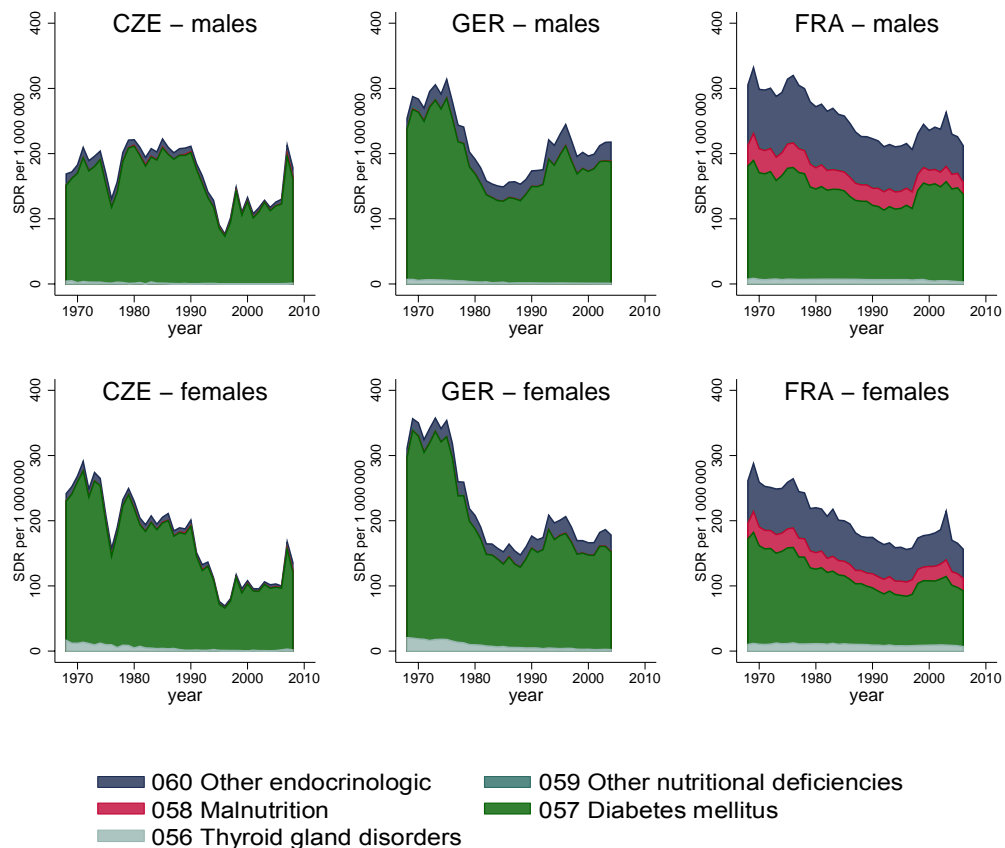
Endocrine, nutritional and metabolic diseases

The overall mortality from the ICD10 4th chapter is mostly dependent on mortality from diabetes (Figure 60). For several reasons, diabetes is also a condition prone to the influences of coding habits. Diabetes is frequent in the elderly population, and it is associated to the major chronic diseases (cardiovascular diseases, hypertension, obesity and diabetes have higher risk to coexist than to exist separately (Reaven 1988). It is therefore very common to find diabetes as

associated cause when multiple causes of death are studied (Wall et al. 2005). Diabetes is however not very often recognized as underlying cause of death and we are not keeping diabetes or any other cause from chapter IV in our list.

In France, malnutrition and other endocrinologic disease form significantly higher part of chapter IV than in the two remaining countries, contributing (once again) to the higher heterogeneity of French cause-specific mortality profile.

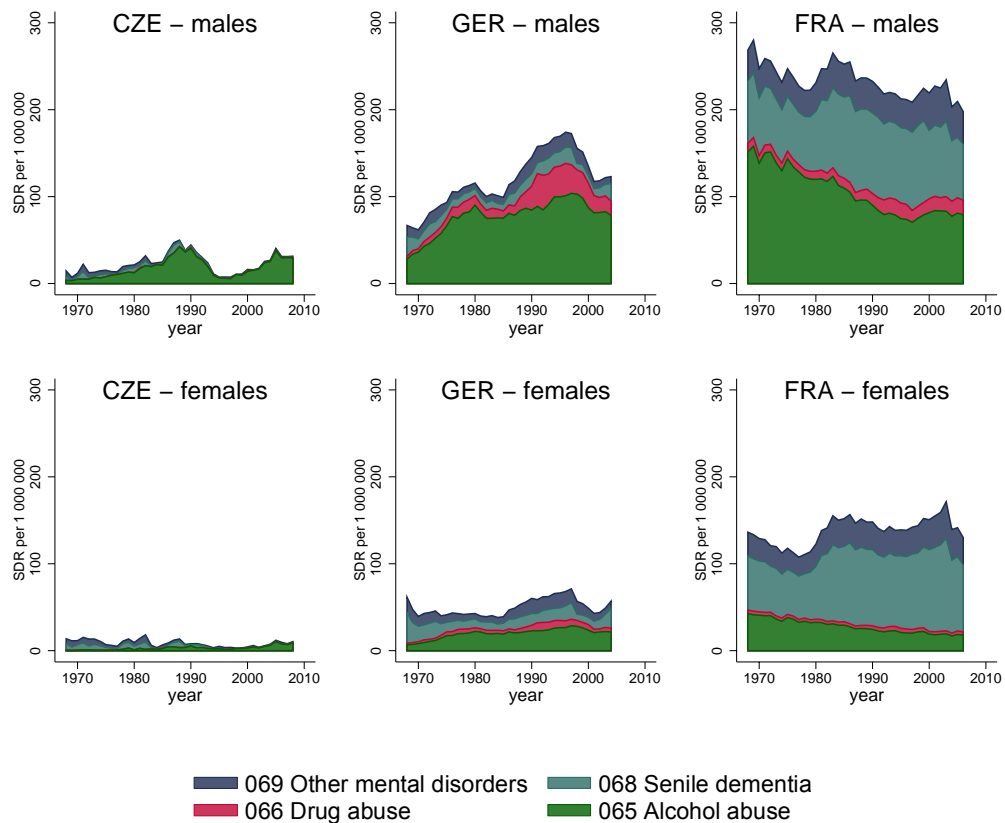
Figure 60 Chapter 4 Endocrine, nutritional and metabolic diseases



Mental and behavioural disorders

ICD10 Chapter V of mental and behavioural disorders consists of a mixture of various pathologies with diverse underlying factors and manifestations. The most present disease here is the abuse of alcohol and drugs, which is very low for both sexes in the Czech Republic and the highest in French males (Figure 60). This cause has without any doubt its place in concepts evaluating the impact of alcohol on mortality, but will not be considered in our analytical list.

This chapter also contains death classified as senile dementia. In France, these rather ill-defined category represents an important part, while in the other two countries coding to this cause is very low.

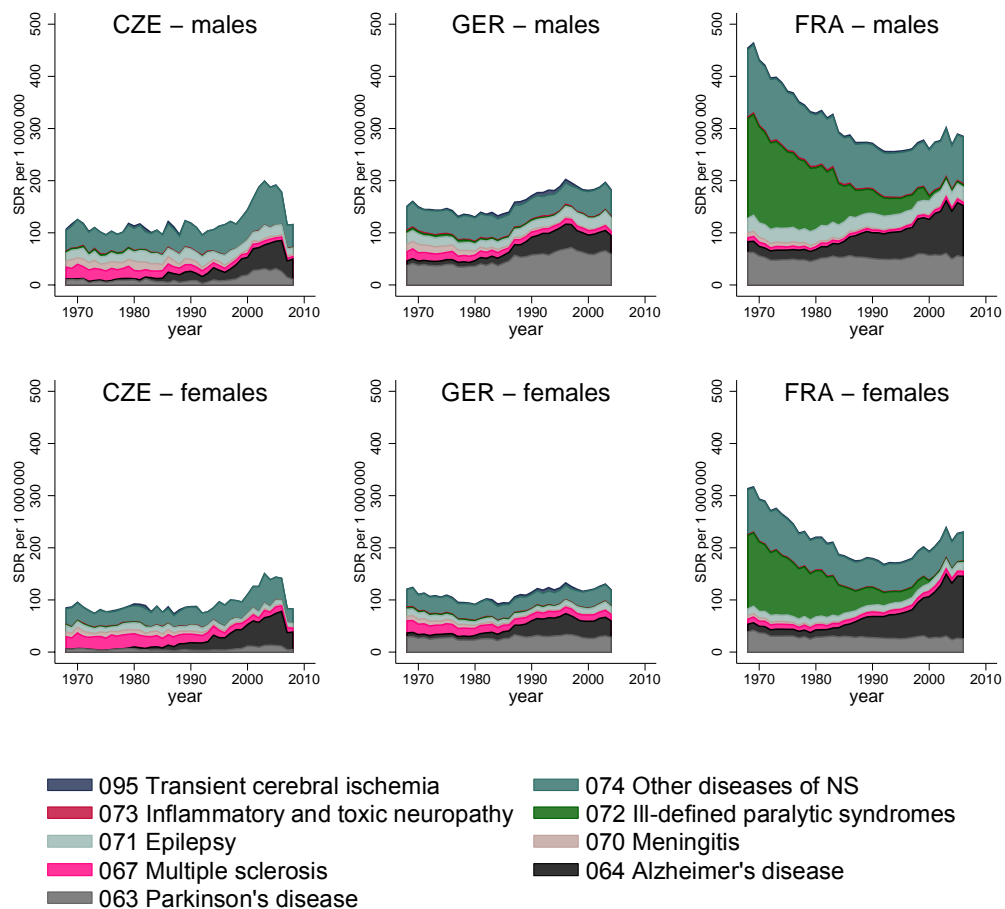
Figure 61 Chapter 5 Mental and behavioural disorders

Diseases of the nervous system

The mortality from the overall chapter of nervous system diseases has recently increased due to rising mortality (and partially rising medical awareness) of Alzheimer's disease, which evolved similarly in all the three countries. West Germany and France have systematically higher mortality from Parkinson's disease than the Czech Republic.

If the whole chapter is considered, France would have much higher mortality than the two remaining countries due to the preference of coding deaths as ill-defined paralytic syndromes, which represent a typical comparability issue: if this ill-defined cause is eliminated from the French data, the mortality structure of nervous system diseases would be similar as in the two other countries (Figure 61). The ICD9 manual also states not to code to ill-defined paralytic syndromes when the cause of paralysis is known, we can therefore assume that the high mortality from ill-defined paralytic syndromes is mainly due to absence of more specific information on the death certificate.

For the analytical list, we will keep the **Alzheimer's disease (item 064)** as a new aspect of mainly old age mortality.

Figure 62 Chapter 6 Diseases of the nervous system

Diseases of the circulatory system

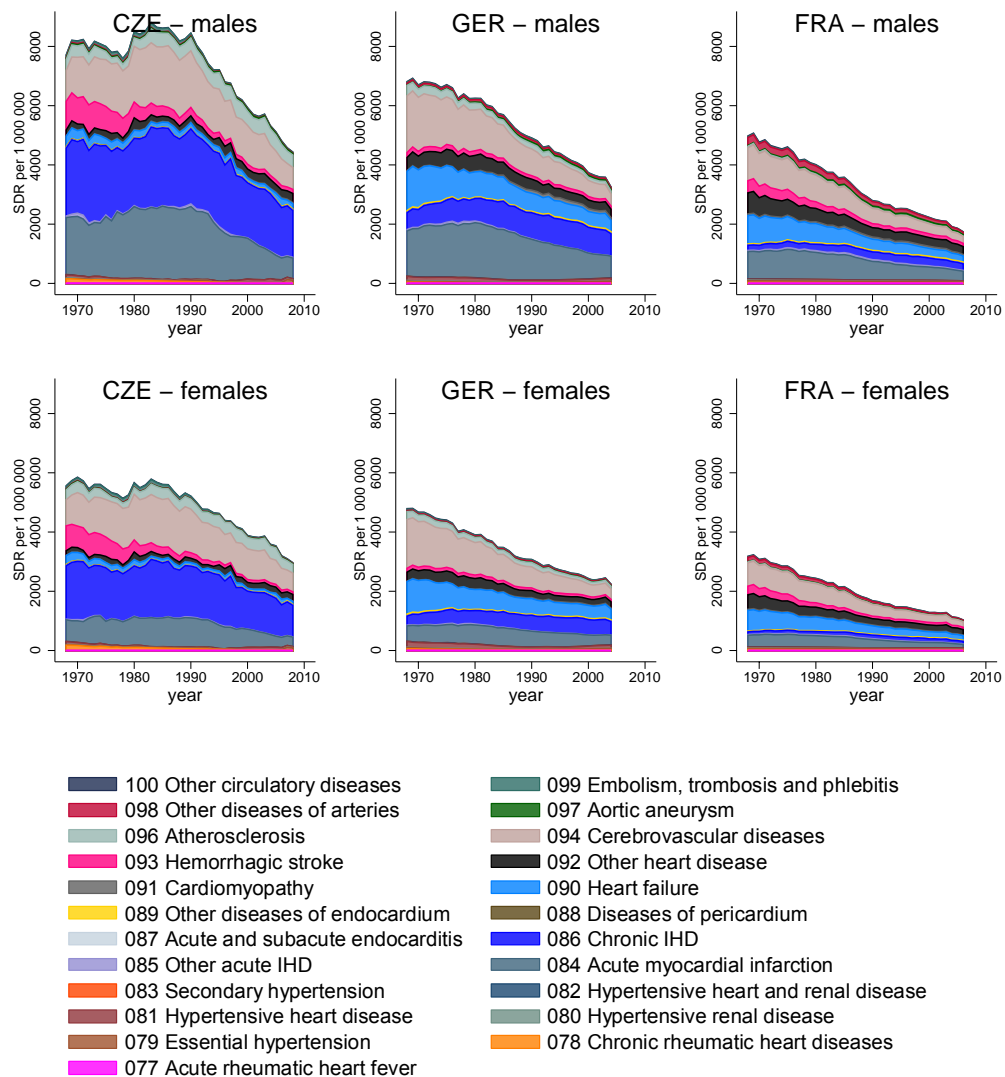
Circulatory diseases have been responsible for most of the mortality change observed throughout the whole period (Figure 63). These statistically most important causes of death, as we could see in the previous chapter, are at the same time the most sensitive to national certification and coding habits.

Many circulatory diseases share common underlying processes, typically atherosclerosis and hypertension. Out of these, atherosclerosis is considered an age-related and to some extent unavoidable degenerative process, which starts as early as we are born (Oliveira et al.). Advanced stages of atherosclerosis result in diverse clinical manifestations depending on the localization of the atheroma plaques; most affected are coronary and cerebral arteries. The first problem with the chapter of circulatory diseases therefore is that it contains the atherosclerosis itself, which is more an etiological underlying process, and her major clinical manifestations (acute and chronic ischemic heart disease and stroke) at the same time.

In the ICD coding rules for *linkage* between causes of death, atherosclerosis links with hypertension, ischemic heart disease, ill-defined descriptions and complications of heart disease and cerebrovascular diseases (i.e. if these causes are listed along with atherosclerosis, regardless of the order on the death certificate the other cause is selected). It could be that in the Czech Republic, where excessive coding of atherosclerosis has been reported prior to 2006 (which we

attempted to correct it in the frame of transition to ICD10) was due to the lack of compliance to these exceptions from coding rules.

Figure 63 Chapter 9 Diseases of the circulatory system



On the other side, in the two Western countries in our file, coding to atherosclerosis has been minimal and its major manifestations have been preferred. Moreover, much bigger portion of cardiovascular deaths in West Germany and France is due to heart failure. Heart failure as an ICD term was first used in the 9th revision. It is defined as a condition, where damaged heart cannot “pump” sufficient volume of blood to the body. Major cause of heart failure is ischemic heart disease, followed by hypertension and diabetes (Soufer 1992). Whether the high mortality from heart failure observed in West Germany and France is a real result of surviving ischemic heart disease and developing another stage of heart disease – heart failure – or whether it is a matter of certification/coding habits is not clear at the moment. In order to obtain the most coherent information, we propose therefore to study these groups of cardiovascular diseases:

- **acute myocardial infarction (items 084-085)** as one of the most coherent causes of death in time and as a specific case of heart disease: in up to 50% of the patients it is

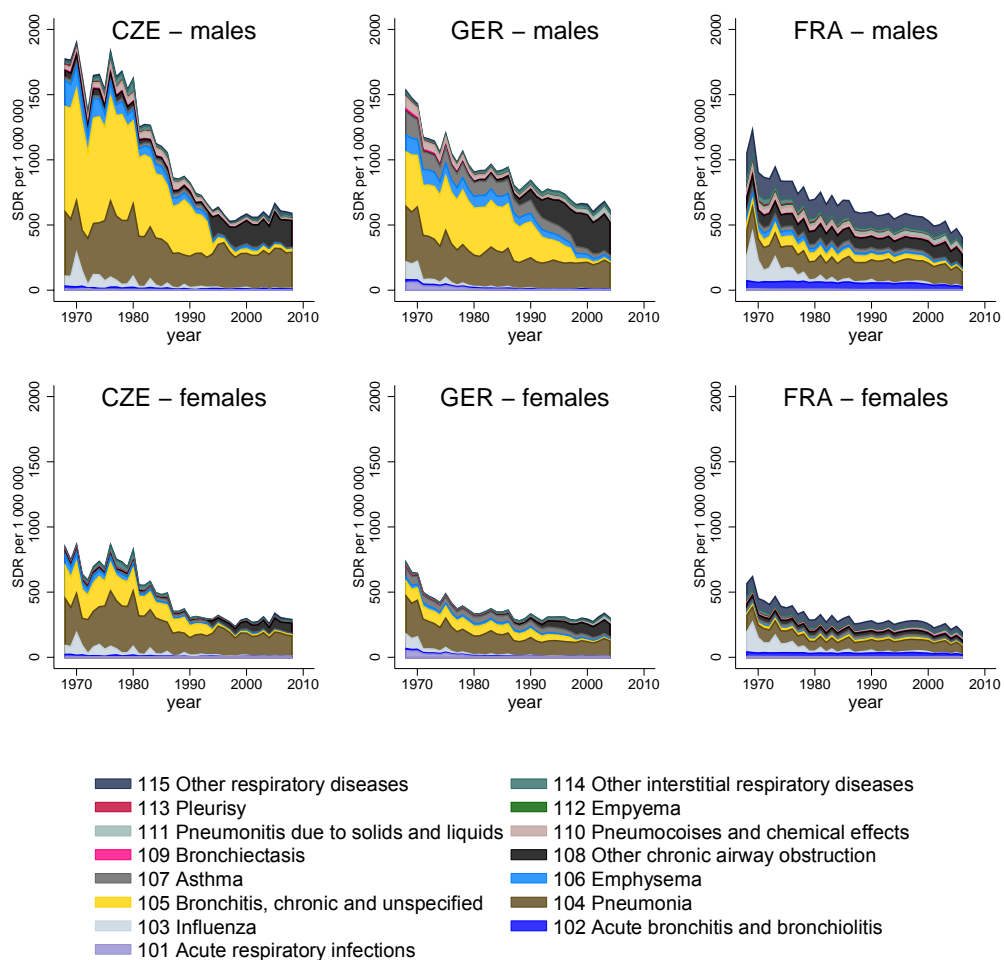
the first manifestation of ischemic heart disease. The most effective cure for all forms of AMI is PTCA (percutaneous transluminal coronary angioplasty), available in a large scale since the 1990s

- **chronic heart diseases complex (items 086-092)** as a group encompassing mainly ischemic chronic heart disease and heart failure, followed by other heart diseases of the 186-shortlist
- **cerebrovascular diseases (items 093-094)** without distinction of hemorrhagic or other stroke
- **other circulatory diseases (items 077-083, 095-100)**

Diseases of the respiratory system

Statistically speaking, the respiratory diseases are the third most important group of causes of death. They also underwent significant decline and unanimously contributed to the mortality decrease.

Figure 64 Chapter 10 Diseases of the respiratory system



The chapter is a mixture of infectious, environmental, chronic and other diseases (Figure 64). The major infectious diseases of chapter X are influenza and pneumonia. The influenza mortality (along with other acute respiratory infections) decreased, while pneumonia occupies a stable position in the respiratory mortality. Most of the chapter decline in the Czech Republic

and West Germany was due to chronic and unspecified bronchitis. After adoption of ICD10, a part of deaths from chronic bronchitis passed to other chronic airways obstruction, which can be seen in Czech Republic and in West Germany. The French series, reconstructed via double-coding coefficients, show regular distribution of respiratory mortality among pneumonia, chronic airways obstruction and the rest. This could be partially an artefact of the double coding, which uses all the reported links between causes and therefore tends to more regular redistribution.

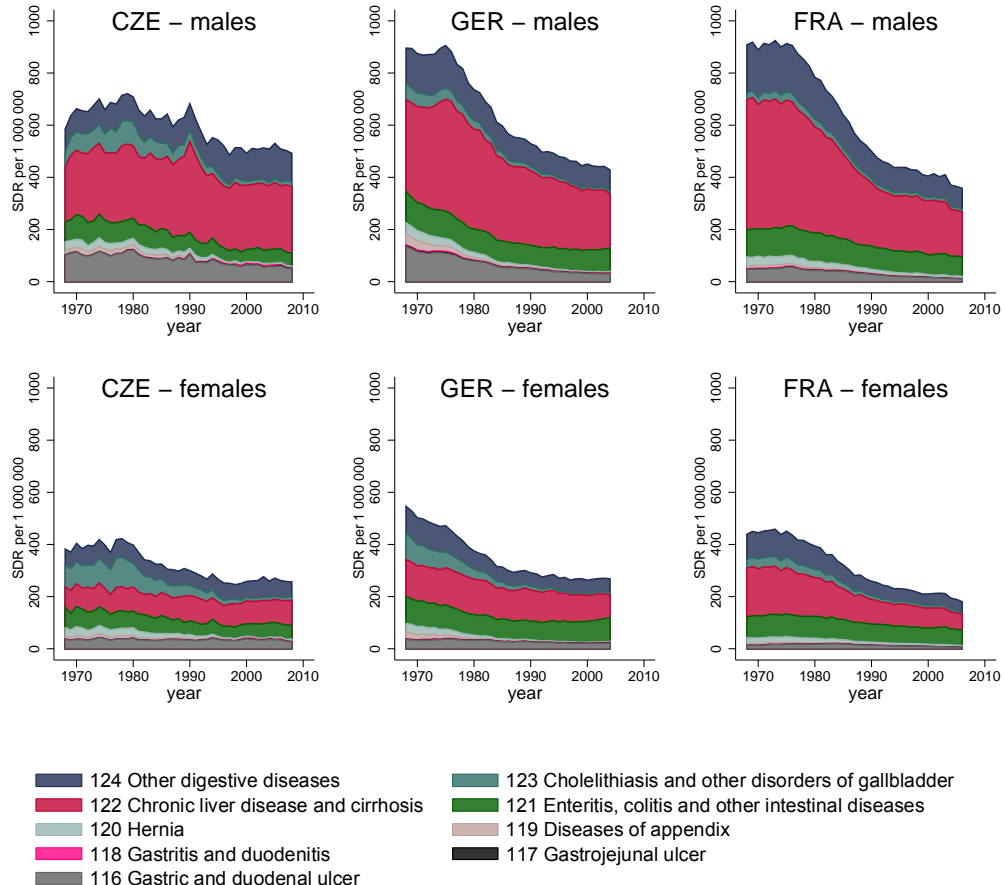
From the chapter of respiratory disease these groups will be extracted:

- **Pneumonia (item 104)** as potentially end-stage disease in the elderly and immunocompromised population
- **Chronic obstructive pulmonary disease (items 150-109)** as a broader concept which usually encompasses chronic bronchitis, emphysema and asthma. To these three causes we add other chronic airways obstruction and bronchiectasis.
- **Influenza (item 103)**

Diseases of the digestive system

Within the chapter of the diseases of digestive system, **chronic liver disease and cirrhosis** plays the major role and is responsible both most of the chapter mortality movement and for the international/intersex differences and will therefore be kept as the only disease (Figure 65).

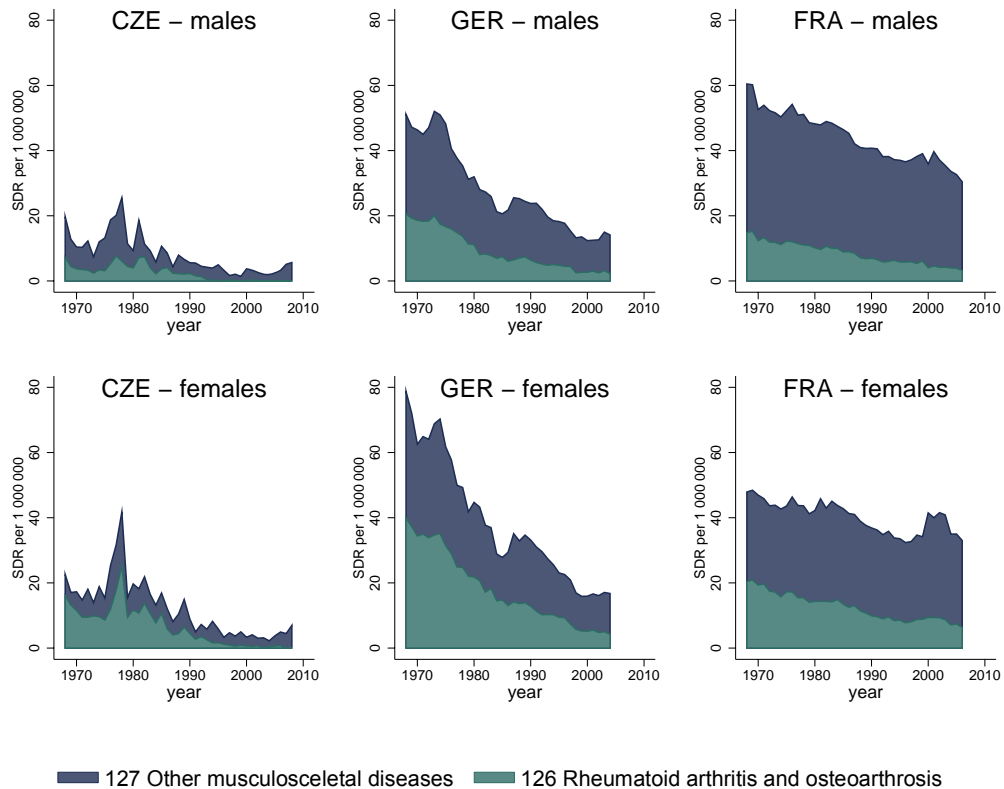
Figure 65 Chapter 11 Diseases of the digestive system



Diseases of the musculoskeletal system and connective tissue

The mortality from diseases contained in this chapter is very low. The highest mortality can be found in France. For both sexes, mortality is the lowest in the Czech Republic (Figure 66). This finding brings another evidence to the claim that French certifiers or coder use different (and larger) file of ICD items for mortality coding.

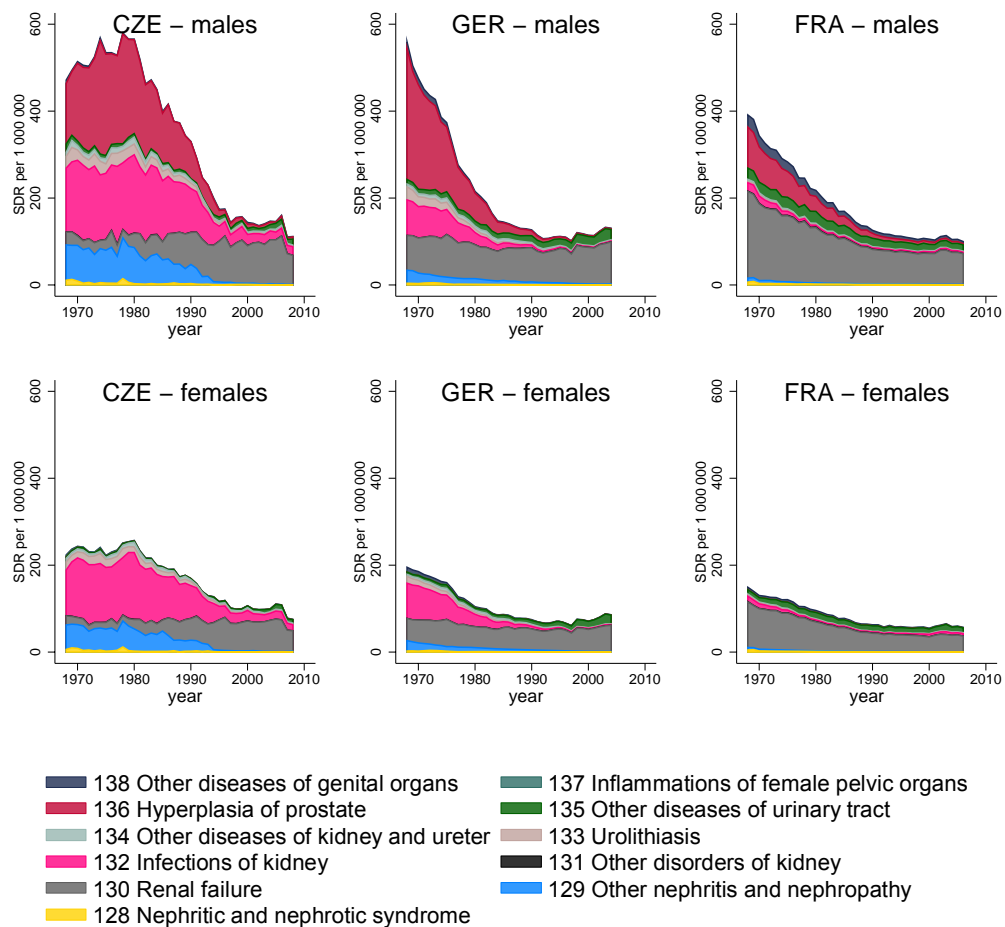
Figure 66 Chapter 13 Diseases of the musculoskeletal system and connective tissue



Diseases of the genitourinary system

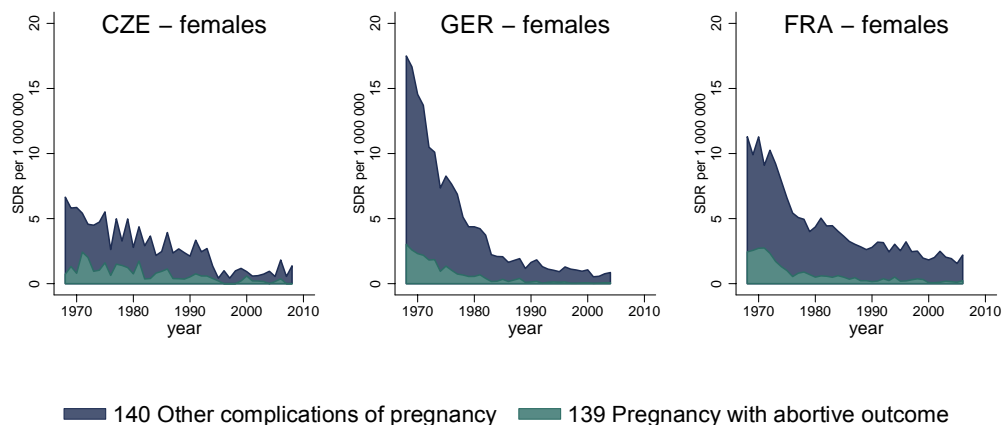
Genitourinary diseases are formed by two large groups: diseases of kidney, and hyperplasia of prostate in males. While prostate hyperplasia underlied the spectacular decrease of mortality from this chapter in males, in both sexes a decrease in mortality came mainly from renal diseases (Figure 67). The structure of renal diseases' coding across countries is however different: in the Czech Republic and West Germany, infections of kidney are strongly present until 1990s, in Czech Republic a strong part was also attributed to other nephritis and nephropathy. In France, all the renal diseases fall mainly in the category of renal failure. With regard to comparability, this chapter stands the worst from what was seen so far. To eliminate the impact of these different cause-of-death structures, we will keep:

- **hyperplasia of prostate (item 136)** as a factor of large inter-country differences before 1990s
- **renal diseases (item 128-134)** as another contributor to mortality decrease over time

Figure 67 Chapter 14 Diseases of the genitourinary system

Pregnancy, childbirth and the puerperium

Except for study of maternal mortality, deaths from this chapter are not of special interest for demographic study. Very low in death counts, interesting is that maternal mortality has still been a bit higher in West Germany by the end of 1960s, but quickly declined to recent levels close to 0 (Figure 68).

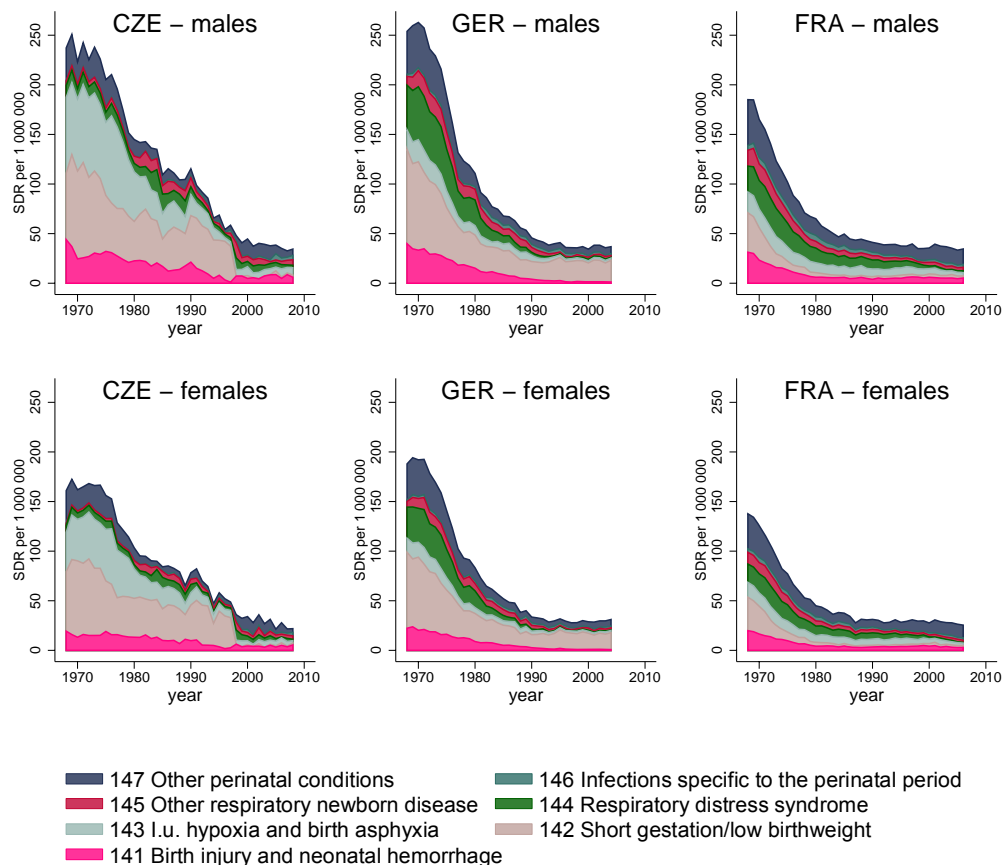
Figure 68 Chapter 15 Pregnancy, childbirth and the puerperium

Certain conditions originating in the perinatal period

Among all causes of ICD, the chapter of perinatal causes went through the biggest decline within the period of observation (Figure 69). In the end, similarly low mortality levels were attained, but France clearly was at a more advanced stage since the beginning. The perinatal mortality decline was the most rapid in West Germany, and less steep in the Czech Republic. Lagging of the Czech Republic and West Germany after France can be explained by resistance to reduce the mortality of premature newborn (short gestation/low birthweight), and in the Czech Republic also birth-related complications (intrauterine hypoxia and birth asphyxia). Although, these interpretations can be influenced by possible undercoding of respiratory distress syndrome in the Czech Republic.

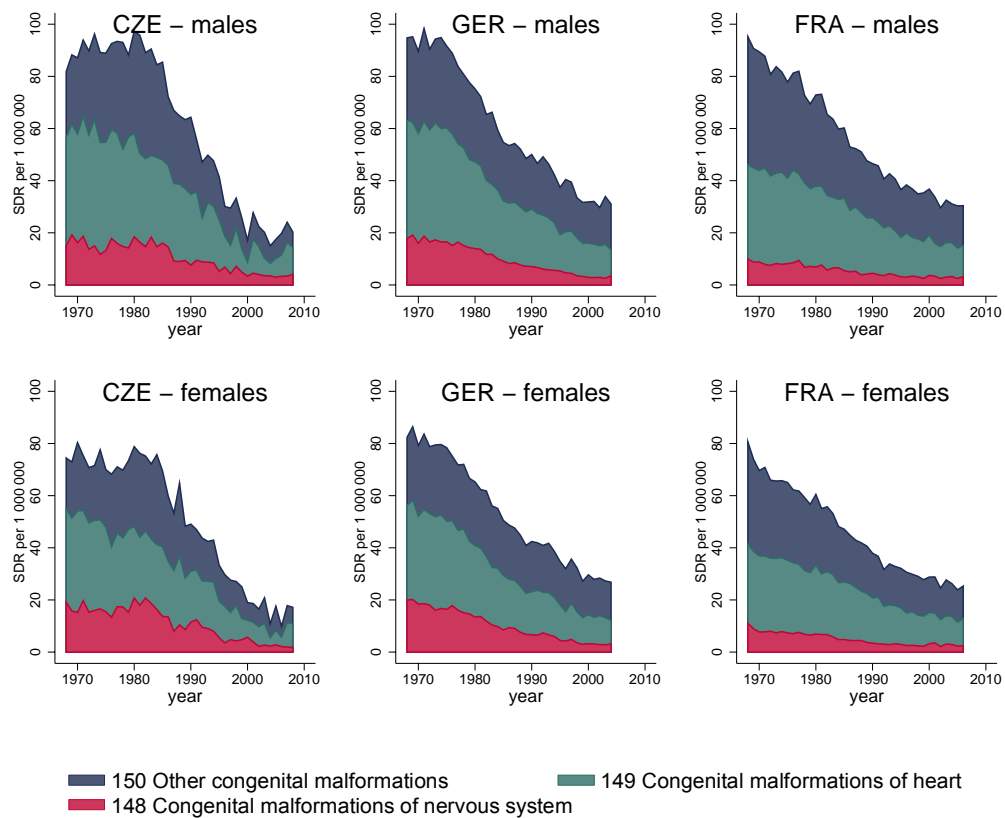
For the analytical list, the chapter of perinatal causes of death will be considered as a whole.

Figure 69 Chapter 16 Certain conditions originating in the perinatal period



Congenital malformations, deformations and chromosomal abnormalities

The mortality from congenital malformations has regular structure composed of congenital malformations of heart, nervous system and other organs. As for perinatal causes, this chapter underwent spectacular decline and the lowest levels were achieved recently in the Czech Republic (Figure 70). Concerning the analytical list, congenital malformations will be added to perinatal causes as diseases of infancy (although due to medical progress the life span of newborns affected by congenital malformations increases).

Figure 70 Chapter 17 Congenital malformations, deformations and chromosomal abnormalities

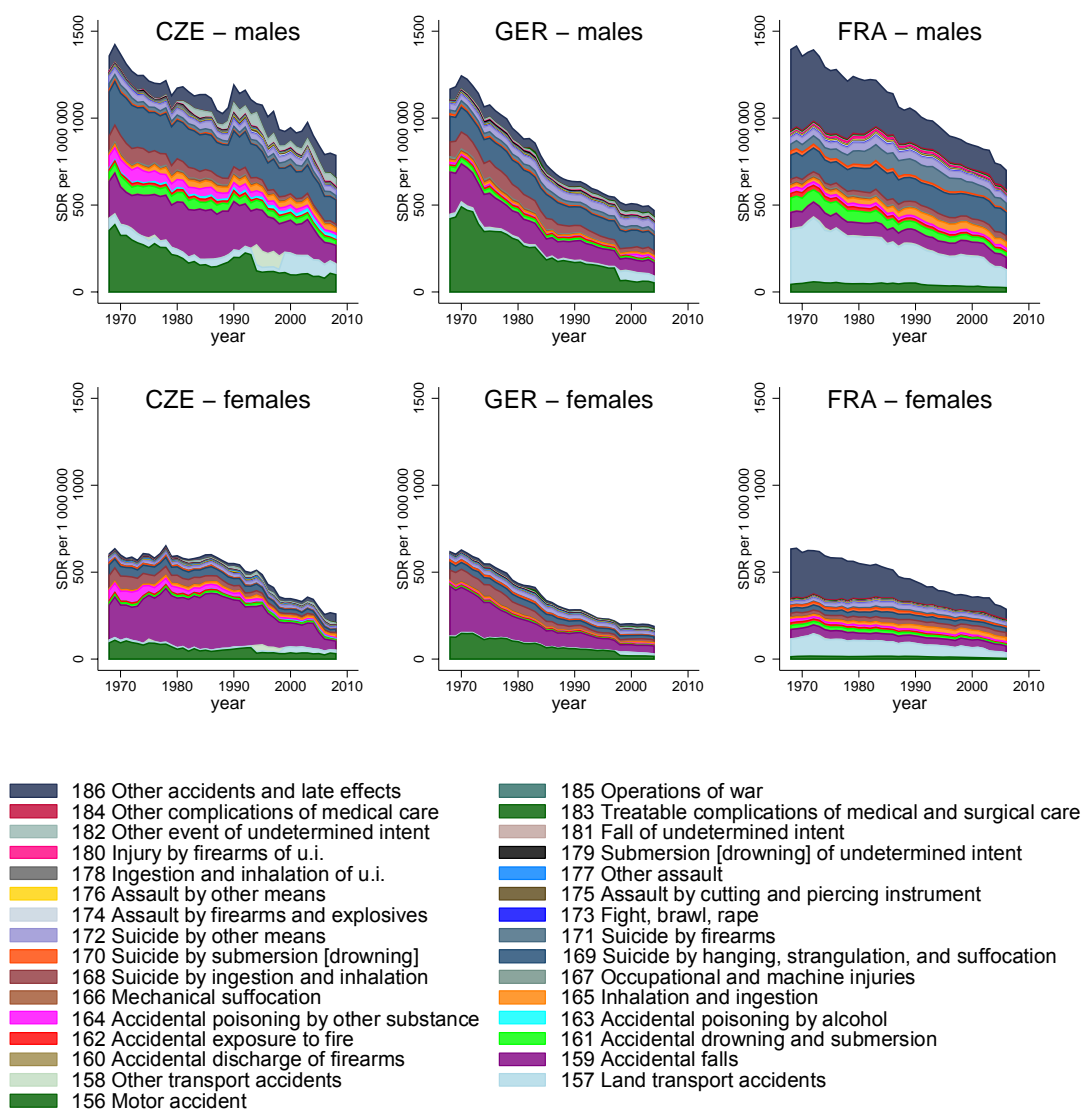
After redistribution of ill-defined causes of death, only one cause left from this chapter – the SIDS. Because SIDS is a diseases limited to first year of life, it will be added to the category of **diseases of infancy (items 141-151)**.

External causes of morbidity and mortality

Diverse problems with ICD10 transition for accidental mortality have already been mentioned in chapter IV. In Figure 71 the results come in the full view: the difficult separation of motor and land transport accidents and change in the coding of accidental falls are the most visible. In France the reconstructed series show remarkable excess of the residual category of accidents (Figure 71).

Therefore, a broader aggregation according to the “etiology” of the injury is proposed:

- **traffic accidents (items 156-158)**
- **suicide (items 168-172)**
- **assault (items 173-177)**
- **other accidents (items 159-164,186)**

Figure 71 Chapter 20 External causes of morbidity and mortality

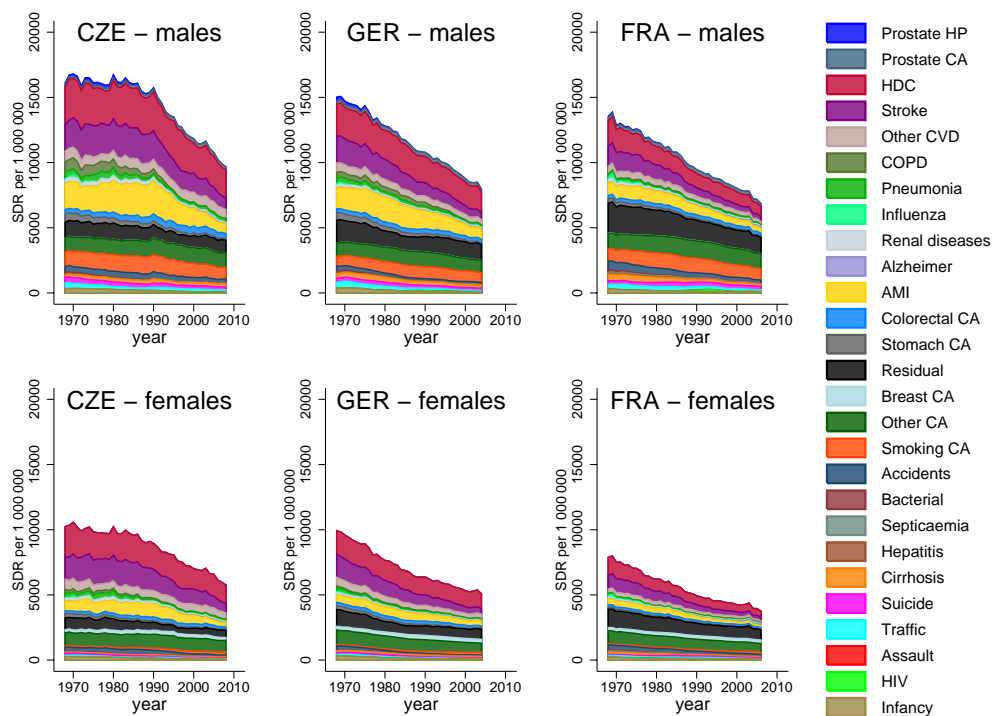
Overview of the selected diseases

A total of 27 items were extracted. Out of these, 26 items have specific reason for inclusion, and are believed as reliable and comparable data source. The residual category is a mixture of all other causes across ICD, either of no special interest, low death counts, or unspecific profile.

The last figure in this chapter gives an overview at the overall SDR, this time divided into the subset of 27 items that were just selected for further analyses (Figure 72). It can be seen that the first 26 causes which we believe as reliable, comparative and informative, contain important part of the toll of mortality in West Germany and the Czech Republic. The remaining group of various causes is then, as expected, more present in France. Compared to the simplistic breakdown into main ICD chapters, the hegemony of the group of circulatory diseases disappears and divergent movements within the chapter of cancer can be detected.

In the next chapter, the ordering of the selected diseases will be explained. The colour scheme as applied in Figure 72 will be constant for the rest of the presented study.

Figure 72 SDR by the 27 selected causes of death



Chapter VI.

Life table analysis

The three countries of our interest have never been put aside for a direct cause-specific comparison. Rychtaříková et al. (1989) published a comparative study of mortality trends in France and Czech Republic between 1950 and 1985, while the post-war mortality in France and West Germany until 1995 was compared by Haudidier (Haudidier 2005). All the three countries stand together in an exhaustive systematic comparative overview of trends in mortality and differential mortality in European countries by (Vallin et al. 2001), but no special attention there is paid to their mutual comparison. This chapter aims to compare interactions of causes of death with life table mortality indicators – probabilities of death and life expectancy – via the concept of multiple-decrement life tables.

7.1 Overview of all-cause mortality in a broader context

Czech Republic, West Germany, and France entered the 20th century with very different levels of life expectancy at birth (LEB). By the beginning of the 20th century, Czech Republic lagged 4.5 years in male and 5.3 years of female LEB behind France (Rychtaříková et al. 1989) (Table 36). The following five decades have seen record increases in LEB ranging from 20 years for French males up to 25 years for Czech females. After 1950, the life expectancy gains as observed in the first half of the 20th century were never reproduced - throughout the second half of the last century they virtually halved. The highest gain after 1950 has been seen in French females, while both Czech sexes gained the least years of LEB. Due to this lack of survival improvement in the second half of the 20th century, the mortality disadvantage of the Czech males and females against their German and French counterparts remains very significant: life expectancy gap in 2006 is only about 1 year smaller than in 1900.

Table 36 Life expectancy at birth – 20th century

Period	Country	LEB males	LEB females	LEB gain males	LEB gain females
1900	Czech Republic*	38,90	41,70	.	.
1891-1900	Germany**	40,57	43,97	.	.
1900	France	43,40	47,00	.	.
1950	Czech Republic	61,97	66,85	23,07	25,15
1949-1951	West Germany ***	64,56	68,48	23,99	24,51
1950	France	63,43	69,19	20,03	22,19
2006	Czech Republic	73,46	79,87	11,49	13,02
2006	West Germany	77,22	82,27	12,66	13,79
2006	France	77,22	84,15	13,79	14,96

* Rychtaříková et al (1989)

** This figure has only orientation value. It was estimated for years 1891-1900 for the territory of Germany at the time being, i.e. including West Germany, Alsace-Lorraine, East Germany and some parts of Poland (Silesia, West Prussia, Posnania and Ostpreussen) (Haines and Kintner 2000)

*** The data come from the Human Life Table Database, they are for years 1949-1951

Source: Human mortality database, Rychtaříková et al. (1989), (Haines and Kintner 2000), Human life table database

Re-estimation of life tables for period 1953-1964 in the Czech Republic

In order to study correct trends in life expectancy, a correction must be applied to the Czech data. The official Czech mortality data are marked by inconsistency of the definition of live birth. Until 1952, any foetus having heartbeat or breathing was considered a live birth. Between 1953 and 1964 a live birth was defined as a foetus of at least 28 weeks gestation, with a body length of at least 35 cm, a birth weight of at least 1000 grams, and breathing. If not meeting these criteria, surviving of foetus for 24 hours was required to be considered a live birth. In 1965, the notion of gestation length was abandoned and the criteria for a live birth were the presence of any of the three vital signs: breath, heartbeat, umbilical cord pulsation, or definite movement of voluntary muscles. In 1988 the weight criterion was added: if the new-born weighs less than 500g, the birth can be considered as live if only it survives 24 hours after birth (Rychtaříková et al. 2006).

The data on infant deaths were largely affected by the change of definition in 1953, which resulted, according to (Kučera 1966), to a 21% under-estimation of infant mortality.⁸³ In the Human mortality database the infant mortality for the whole period of 1953-1964 was not corrected, and life expectancy at birth is therefore slightly over-estimated.

We made adjustments of infant deaths data according to the result of the double classification by increasing official numbers of infant deaths by 21%. In order to obtain the corrected life table indicators, we recalculated the 1-year life tables for years 1953-1964 according to the HMD methodology. This adjustment resulted in a 0.3-0.4 years lower life expectancy at birth values as compared to the figures published by the CSO. Our results are also by 0.5 years lower than the values corrected for infant mortality definition, published by Rychtaříková et al. (1989). Such discrepancy occurred due to the fact that HMD data are based

⁸³ A dual classification study was performed to quantify the impact of the definition change (Kučera 1966). According to the administrative definition of 1953, the infant mortality rate in 1965 would have been 19.1‰, compared to the 23.7‰ according to the 1965 definition, the difference being due to 700 live births in 1965 that would have been considered spontaneous abortions in 1964 (Rychtaříková et al. 2006).

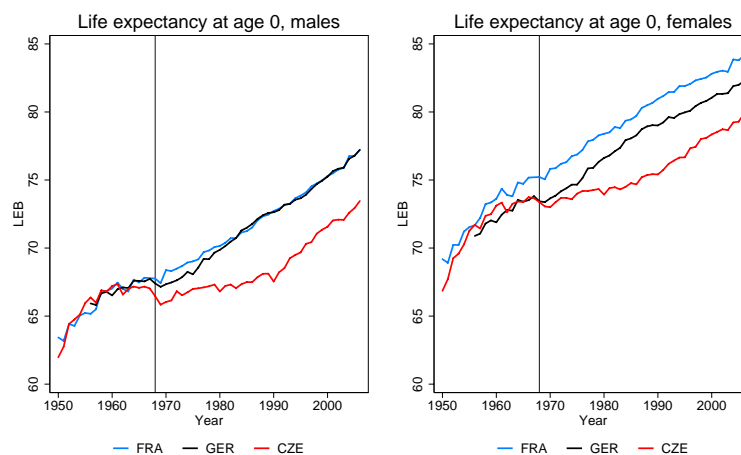
on new intercensal population estimates which are corrected for the incomplete registration of migration in Czech Republic (Rychtaříková et al. 2006). It has been shown that unregistered emigration in Czech Republic in the 1950s led to notable overestimation of population according to the official post-census population estimates. Therefore, there are significant discontinuities in population counts at census years. The corrected life tables as well as comparison of the three results of life expectancy at birth for years 1953-1964 are given in the Annex.

Trends in all-cause mortality since 1950

In this section we will inspect the changes of mortality after 1950. Unless otherwise stated, the HMD has been used as the only source for all life table information except for the Czech Republic in 1953-1964.

Figure 73 shows the evolution of life expectancy at birth after 1950. The most remarkable is that after the steep LEB rise of the 1950s, in 1960 the differences between the three countries were still minimal, following a general pattern of convergence as observed in most of the developed world (Vallin and Meslé 2004). During the next decade the progress of LEB either slowed down or stopped in all the three countries. The end of the 1960s then represents the beginning of strong divergence between France and West Germany on one side, where life expectancy recovered, and the Czech Republic on the other side, where life expectancy suddenly decreased and then stagnated for the next twenty years to come. This onset of the divergences also coincides with the adoption of ICD8 – later we will therefore be able to see which causes of death driven the increase and the consequent decrease of this gap observed since the 1960s.

Figure 73 Trends in life expectancy at birth, 1950-2006



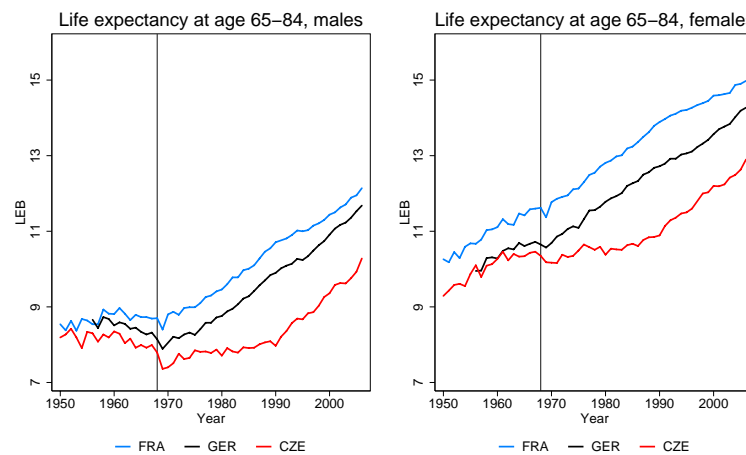
Note: the vertical line is placed at the point from which the cause-specific data are available

Specific mortality patterns of advanced ages

It is known that mortality profiles of the past, and yet in 1950s and 1960s, were largely influenced by infant mortality. The life expectancy at birth is an aggregate indicator of mortality constructed in a way which puts more importance on lives saved at early age. Therefore, its interpretation in a long-term, when the age structure of deaths changes considerably, may be

misleading. Focusing on older ages provides a clearer picture of mortality at its modal age range⁸⁴. Figure 74 depicts the evolution of temporary life expectancy between age 65 and 84. Some differences become apparent. Compared to the life expectancy at birth, for old ages we see: 1) no signs of improvement in the 1950s for elderly males, 2) no signs of convergence for either of sexes, 3) a clear **deterioration** of male survival in **all** the three countries during the whole period of 1960s⁸⁵, and 4) a much more pronounced advantage of French females.

Figure 74 Trends in life expectancy between ages 65 and 84, 1950-2006



Note: the vertical line is placed at the point from which the reconstructed cause-specific data are available

7.1.1 Uneven distribution of mortality progress

This discrepancy of trends in life expectancy at different ages calls for decomposition by age groups. The gains/losses in life expectancy at birth were decomposed using the method of Andreev in order to compare the age-specific contributions to change in life expectancy at birth in several post-war periods. The applied formula (Andreev 1982)⁸⁶ is the following:

$$e_0^2 - e_0^1 = \frac{1}{2} \cdot \sum_{x=0}^{\omega} \{ [l_x^2(e_x^2 - e_x^1) - l_{x+1}^2(e_{x+1}^2 - e_{x+1}^1)] - [l_x^1(e_x^1 - e_x^2) - l_{x+1}^1(e_{x+1}^1 - e_{x+1}^2)] \},$$

where l_x and e_x are age-specific life table survivors and life expectancy (respectively) for period 1 and 2.

The selection of the years for the decomposition is not evident. From an international perspective, it is tempting, and it is often used to consider three post-war periods of mortality: before the convergence in 1965, between 1965 and 1990 (to see the traces of communism) and after 1990. Observing our six populations in question (2 sexes x 3 countries), and with regard to the specifics of old-age mortality, the decomposition was refined into six quasi-decennial periods in order to capture the age structure of:

⁸⁴ Age groups around the modal age at death.

⁸⁵ Unfortunately, our cause-specific data do not cover this period of deterioration.

⁸⁶ Similar decomposition methods were proposed by other authors as well: (Pressat 1985), (Arriaga 1984) to cite a few.

- the common and rapid life expectancy increase in the 1950s (1950-1960)
- the stagnation or decline of the 1960s observed in all male populations of the three countries (1960-1971)⁸⁷
- the quick recovery of the French and German populations in the 1970s (1971-1980)
- the slow recovery of the Czech females before the fall of communism (1980-1990)
- the Czech mortality turnover in the 1990s (1990-2000)
- the most recent mortality trends (2000-2006)

For greater convenience, these periods are of approximately similar length. The results can therefore be represented and interpreted without further adjustments (however, the last 7-years period was left as such not to anticipate future developments).

The results of the decomposition by each period are presented in the bar plots. To increase the visibility of contributions at higher ages, the y-scale maximum has been set to 1. The contributions of infant mortality from the 1950s are therefore not fully displayed. Their values, along with the overall changes, are given in Table 37.

Table 37 Change in LEB and contributions of age 0

	Czech Republic			West Germany			France		
Year	LEB	Change	Age 0	LEB	Change	Age 0	LEB	Change	Age 0
MALES									
1950	61.97	.	.	64.56	.	.	63.43	.	.
1960	67.21	5.24	3.01	66.52	1.96	1.66	67.03	3.60	1.86
1971	66.15	-1.06	0.19	67.47	0.95	0.82	68.31	1.28	0.76
1980	66.81	0.66	0.40	69.87	2.40	0.80	70.16	1.85	0.53
1990	67.54	0.73	0.39	72.63	2.76	0.45	72.73	2.57	0.25
2000	71.57	4.03	0.55	75.25	2.62	0.24	75.29	2.56	0.26
2006	73.46	1.89	0.06	77.22	1.97	0.05	77.22	1.93	0.06
FEMALES									
1950	66.85	.	.	68.48	.	.	69.19	.	.
1960	73.12	6.27	2.72	71.89	3.41	1.40	73.62	4.43	1.55
1971	73.37	0.25	0.20	73.85	1.96	0.74	75.87	2.25	0.63
1980	73.93	0.56	0.29	76.62	2.77	0.65	78.40	2.53	0.48
1990	75.41	1.48	0.29	79.01	2.39	0.41	80.97	2.57	0.20
2000	78.35	2.94	0.44	81.05	2.04	0.18	82.81	1.84	0.21
2006	79.87	1.52	0.06	82.27	1.22	0.03	84.15	1.34	0.05

1950-1960: Persistence of pre-war patterns of mortality decline

The first decade after 1950 was marked by a record-breaking rise of life expectancies, driven by fast reductions of infant mortality. The biggest rise in life expectancy took place in Czech Republic, two thirds of these improvements were nevertheless attributable to reductions of infant mortality, which itself caused a gain equal to 3 years. In all the three male populations, consistent positive contributions were observed for young and adult ages. Males aged 50 years and more showed much smaller, but positive contributions in Czech Republic and France, while

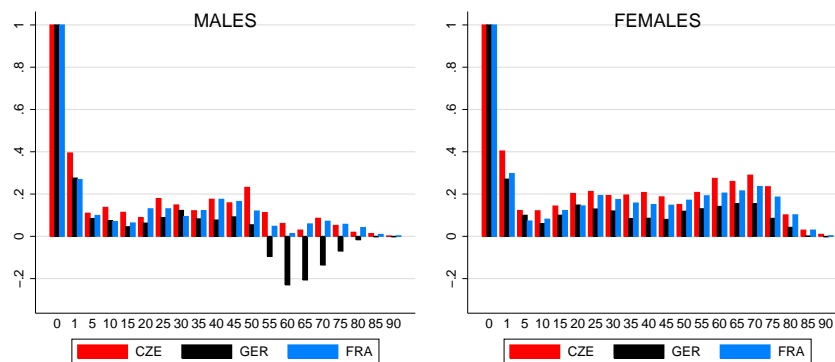
⁸⁷ The year 1971 instead of 1970 was taken because of the pandemic of Hong Kong influenza, which increased the mortality temporarily in 1968-1970. I suppose that the year 1971 reflects better the general mortality profile of the period.

in West Germany a serious mortality increase occurred for the age group 55-74. This specific trend was explained by persisting effects of the WW2 (such as consequences of health selection into the army (Haudidier 1996). Later, other authors pointed at data quality problems in the 1950s (the German census of 1951 lasted several months and individuals from mobile adult age groups could have been enumerated more than once (Luy 2004)), which could have added more (artificial) magnitude to the effects of war.

The age pattern of the improvement of female life expectancy was the same in all the three countries in question: bimodal distribution with first maximum of contributions at childbearing ages (20-29) and second maximum at retirement ages (60-69). The 1950s also saw the biggest decennial life expectancy increase in our dataset: 6.3 years of gain for Czech females, out of which 2.7 due to infant mortality.

It could be generalized that the mortality improvements brought by the 1950s were quantitatively enormous, but qualitatively resembled the past.

Figure 75 Decomposition of change in LEB between 1950 and 1960



Note: Age-specific contributions of age 0 were cut to the value of 1. See Table 37 for full information.

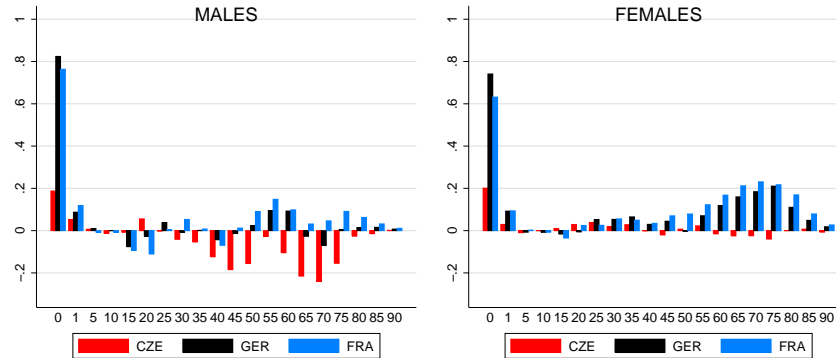
1960-1971: Dividing the mortality trajectories

While, in spite of quantitative differences, common age patterns of mortality change emerged in 1950s, the 1960s divided the mortality trends into the “Western” and the “Eastern” model. The decade of 1960s represented worsening health situation among Czech males: within ten years the life expectancy at birth dropped by 1 year to reach its lowest level in the second half of the 20th century. Virtually all that had been gained in adult male mortality during the 1950s has been lost in the 1960s. For ages above 60, the losses even exceeded the previous gains. Finally, even after correction of infant mortality, the contributions of age 0 are also minimal, suggesting that the deterioration was of general character. The cause-of-death patterns presented in Rychtaříková et al. (1989) show that the 1960s deterioration of survival in Czech males resulted from progressive interplay between a decelerating decline of infectious mortality and rapid venue of man-made mortality - cardiovascular, respiratory, cancer and accidental.

On the other side of the iron curtain the mortality progress slowed down as well due to deterioration of survival in young adults and only modest (France) or negative (West Germany) contributions from the elderly aged 60 years and more. The Czech females were also affected by the 1960s crisis: historically lowest gain in life expectancy, practically exclusively driven by already low improvement of infant mortality, was accompanied by deterioration of old-age

mortality. Meanwhile, in France and in West Germany, very low contributions to female life expectancy change were observed for adult age groups, while for the elderly, the contributions were as important as those of 1950s (for age under 70) - or even greater (for ages above 70).

Figure 76 Decomposition of change in LEB between 1960 and 1971

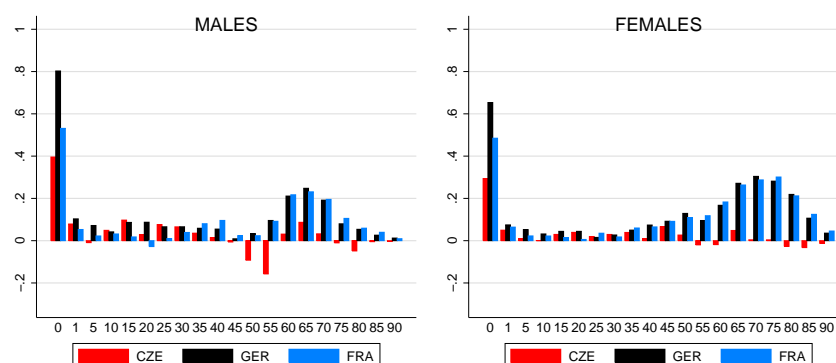


1971-1980: Stabilization of contrasts

After the decade of hesitation, and after the recovery from the epidemics of the Hong Kong influenza (responsible for the so far last pandemic in the developed world in 1968-1970), a stable male mortality decline has begun in France and West Germany driven initially by the elderly aged 65-69. In contrary, the 1970s in Czech Republic brought further deterioration of male adult mortality (30-59 years), although a slight improvement occurred in males above 60 years.

The Czech female life expectancy rose by only 0.5 years between 1971-1980, 60% (0.3 years) being due to further decrease of infant mortality, while the contributions of the old ages were virtually null. In West Germany, the same period brought the biggest life expectancy increase since the 1950s: due to improvements of the elderly female mortality (65-74 years), the total gain was of 2.77 years. Similar age-specific pattern of contributions led to a 2.53 years increase in French female life expectancy.

Figure 77 Decomposition of change in LEB between 1971 and 1980



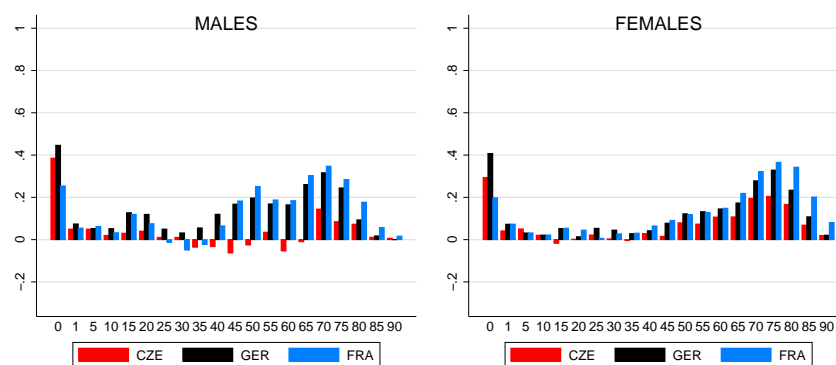
1980-1990: End of health crises

The 1980s represented another big step forward for both sexes in France and West Germany: in both countries the gains were the highest since the 1950s, but this time with main

contributions of age group 70-74 and the two neighbouring age groups. The rise of life expectancy in the two countries was also similarly supported by high contributions of men aged 50-54 and further improvements of mortality of young adults aged 15-24. Like in the two western countries, males aged 70-74 were also the main actors in the modest life expectancy increase in the Czech Republic. However, this favourable trend was counterbalanced by sustained deterioration of survival of the adults (namely 35-64 years).

In response to previous favourable trends, the French and German female life expectancy at birth rose without any interruptions. Most of the progress was achieved by postponing deaths to increasingly advanced ages. While still deep in the communism, the remarkable decrease of the Czech elderly female mortality (namely at ages 50-89) drove the life expectancy up by one and a half years.

Figure 78 Decomposition of change in LEB between 1980 and 1990



1990-2000: Closing the gap

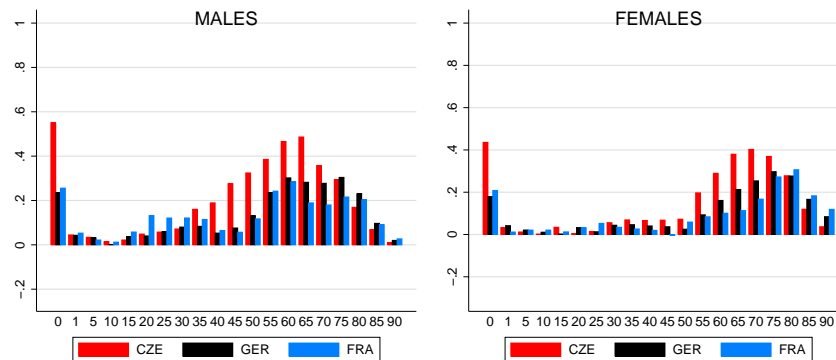
From a historical perspective, the 1980s closed one chapter of the mortality book – this was the last period after the WWII to have seen negative age-specific contributions.⁸⁸ The 1990s saw another life expectancy rise in France and the West Germany. The age-specific contributions were almost evenly distributed among elderly males aged 55-84. As for females, West Germany gained slightly more years of life expectancy than France, especially due to reserves in age group 65-74. In both countries the overall increase of female life expectancy started to slow down.

The reversal observed in the Czech Republic is beyond any comparison. Within 10 years, life expectancy rose by almost 4 years for males, and by 3 year for females. In males, an important part of the rapid recovery came from middle adult ages (40-59). This could be interpreted as a return to the historical potential – the contributions observed in the 1990s roughly correspond to the years of life lost between 1960 and 1990. For ages above 70, there was a reinforcement of health improvements already observed in the 1980s. The most striking feature of age-specific contribution pattern was the reversal of the contributions of age group 60-69 – while negative in the 1980s, during the 1990s this particular age group was one of the most important contributors to the overall male survival progress in the Czech Republic.

⁸⁸ Adult males in Czech Republic and men aged 30-39 in France.

In females, compared to the 1980s, the absolute life expectancy gain in the Czech Republic in the 1990s almost doubled. The most significant increases in the age-specific contributions were observed at the age groups 55-69 and 70+. For both sexes, differently from France and West Germany, infant mortality in the Czech Republic resumed an important role.

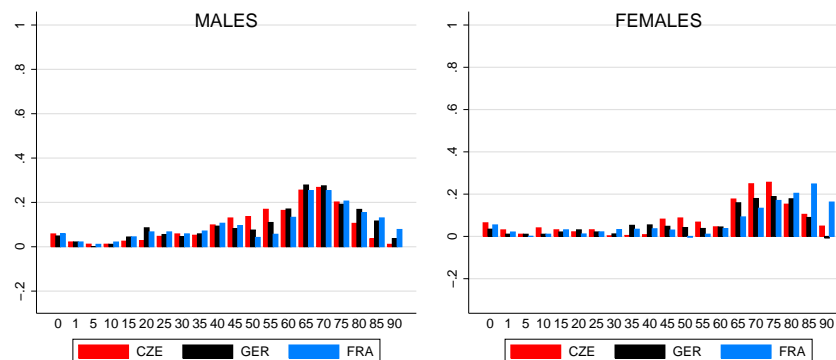
Figure 79 Decomposition of change in LEB between 1990 and 2000



2000-2006: “Aging of mortality decline”

The favourable health trends in the three countries have persisted throughout the most recent years. The period 2000-2006 is shorter, but another shift in the age structure of life expectancy change became evident - the premature mortality slowly loses its role and the toll of mortality improvement depends on increasingly advanced ages. This tendency is present in all the three countries, but the most visible in France. Historically minimal contributions of infant mortality are another common feature of this pattern.

Figure 80 Decomposition of change in LEB between 2000 and 2006



7.1.2 Age-specific probabilities

Age specific probabilities provide more detailed insight into mortality changes after the WWII. We have plotted single-period/year q_x in quasi-three-dimensional matrix plots (known as the Lexis maps).⁸⁹

There is relatively little difference between mortality patterns of females aged 40 years and less: increasing number of young females experience the lowest-low mortality (areas in blue)

⁸⁹ Program Lexis by K. Andreev was used (Andreev 1999).

until increasing age. Young males, in contrary, skip to next level of mortality the year they obtain their driving license and face elevated mortality levels throughout the whole period of adulthood. At these ages, the French males have long been at highest risk of death.

At older ages, the French female mortality is clearly a vanguard population experiencing uninterrupted mortality improvements throughout the whole period of observation. Similar but slower process of improvement was seen in German females as well. From the time perspective, these all-cause data also cover the second postwar decade, marked by radical advances in survival at young and young adult ages. We know from literature (Vallin and Meslé 1988) that this period was still strongly marked by successful fight against infectious disease, which underlied major part of these improvements. In the Czech Republic, these improvements were for long time the only achieved progress against mortality.

Figure 81 Age-specific probabilities of death, males

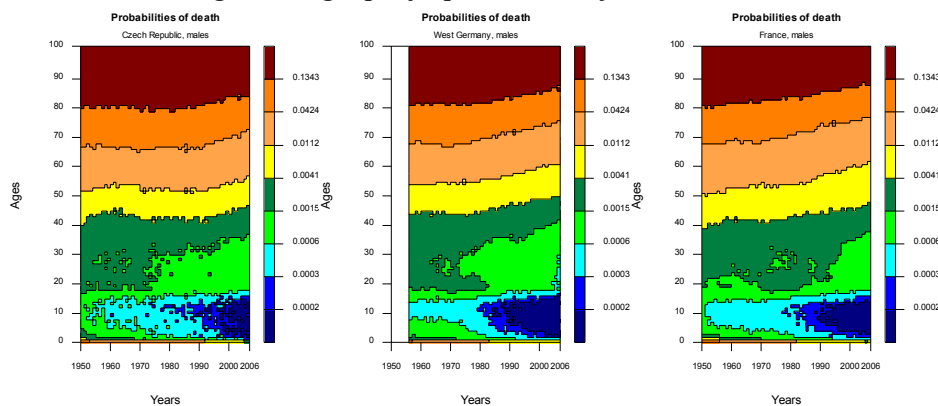
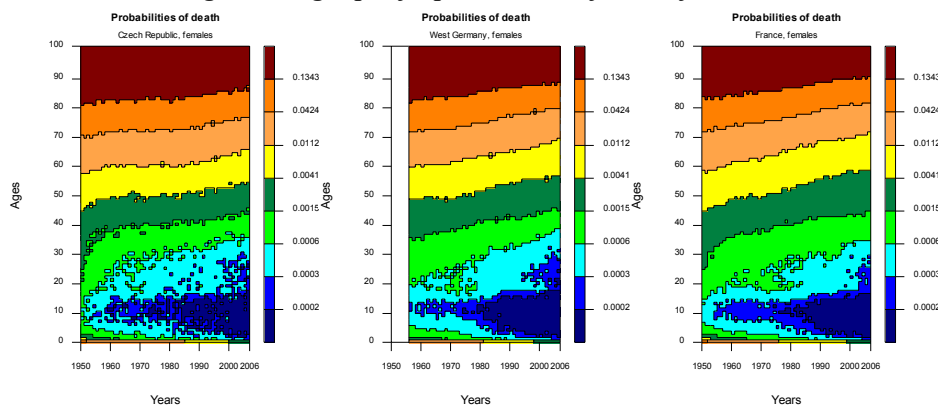


Figure 82 Age-specific probabilities of death, females



In the next section cause-specific data will be applied to mortality surfaces after 1968 in order to determine which pathologic processes stood behind the observed trends

7.2 Causes of death as multiple decrement processes

In all-cause mortality life tables (like the ones available from HMD), only one exit – death – is possible. Reality is although much closer to the situation where death is a result of a competition between multiple causes and surviving means avoiding all these risks. The chapter

V revealed that the cause-specific mortality structures evolve in time, and the first part of this chapter showed that the resulting all-cause mortality disparities were remarkable.

In chapter V we have selected a subset of 27 causes of death. For the study of interaction between such relatively high number of categories and life-table based indicators in time (typically LEB), the multiple decrement life tables techniques seem to be a good choice.

7.2.1 Construction of period multiple decrement life table

First of all, a master period all-cause life table must be constructed. The basic problem in multiple decrement life table is then one of converting the observed age-cause-specific mortality rates (M) into probabilities of exiting the table from various causes. The conversion is performed in following steps:

Let m_x^i be life table mortality rate from cause i at age x :

$$m_x^i = \frac{d_x^i}{L_x}$$

Let M_x^i represent decrement rates from cause i at age x observed in the empirical population:

$$M_x^i = \frac{D_x^i}{E_x} = r_x^i \cdot \frac{D_x}{E_x} = r_x^i \cdot M_x$$

where D_x^i are the observed deaths from cause i , E_x is the exposure – person years lived throughout the age interval. Then r_x^i is the share of deaths from cause i among all causes at age x in the empirical population:

$$r_x^i = \frac{D_x^i}{D_x}$$

It is usually assumed that $m_x^i = M_x^i$, i.e. that life table deaths and empirical deaths are equal. We use the HMD life tables as master tables, and due to various manipulation of the HMD mortality data with intention to increase their quality (corrections, smoothing etc.⁹⁰), the resulting life table might differ from life table directly derived from a simple sum of cause-specific mortality rates. Nevertheless, once we assumed (and accepted) that $m_x^i = M_x^i$ and vice versa, the potential discrepancy between using HMD as master life table and using “proper” life table is not problematic, because during the conversion from empirical to life table cause-specific mortality only the structural component (r_x^i), free from the actual mortality size, is transferred:

⁹⁰ See the protocol of HMD methods (<http://www.mortality.org>)

$$m_x^i = r_x^i \cdot M_x = r_x^i \cdot m_x$$

The probability that those who survived all causes i until age x will exit the life table from cause i in the age interval $[x, x+n)$, where n is the length of the age interval, can be computed directly by multiplying master life table q_x by r_x^i :

$$q_x^i = r_x^i \cdot q_x = \frac{d_x^i}{l_x}, \text{ where } q_x = \sum_i q_x^i$$

Given the relationship between life table death counts, life table death counts due to cause i , d_x^i , can be obtained by multiplying the master life table deaths by r_x^i or as a product of the force of decrement i and the number of those who survived all causes i up to age x . Naturally, at each age, the sum of life table deaths over all decrements equals the master life table d_x :

$$d_x^i = r_x^i \cdot d_x = q_x^i \cdot l_x, \text{ where } d_x = \sum_i d_x^i$$

Summing up life table cause specific deaths d_x^i which occur after age a then gives the number of individuals who will eventually leave the table from cause i after age a :

$$l_a^i = \sum_{x=a}^{\omega} d_x^i$$

For every age we get:

$$l_x^i = \sum_{a=x}^{\omega} d_a^i, \text{ where } l_x = \sum_i l_x^i$$

Share of individuals eventually leaving the life table from cause i among all survivors to age x is then expressed as:

$$\theta_x^i = \frac{l_x^i}{l_x},$$

where $\theta_0^i = \frac{l_0^i}{l_0}$ is interpreted as “the proportion of newborns that will eventually die from cause i under constant age-cause specific death rates” (Preston et al. 2001).

Let us now assume that within each elementary age interval $[x, x+n)$, the average number of years lived in the interval by persons dying in the interval is the same for any cause i . This number would equal the a_x function from the master (HMD) life table. Then the mean age at

death for the given cause i (the life expectancy at age x of those eventually dying from cause i) can be expressed as mean age of those leaving the table from cause i within $[x, x+n)$ weighted by their share on total life table deaths from cause i occurring after age x :

$$e_x^i = \frac{1}{l_x^i} \sum_{x=0}^{\omega} \bar{x}^i d_x^i,$$

$$\text{where } \bar{x}^i = \bar{x} = x + a_x$$

The overall life expectancy at age x can then understood as an average of i -specific mean ages at death weighted by the share of those who will eventually leave the table due to cause i among all survivors to age x .

$$e_x = \sum_i \theta_x^i e_x^i$$

7.2.2 Classification of diseases based on mean ages at death

After calculating multiple decrement life tables for 27 pre-selected causes of death since 1968, simple exploratory analysis was performed on the file of cause-specific mean ages at death. Hierarchical cluster analysis⁹¹ was performed on 27 causes of death (observations), for cause-specific mean ages at death (values) computed for all available years (variables). Each country and sex was processed separately, in order to see whether the selected diseases show some common underlying age-related patterns.

The values of e_x^i without transformation to Z scores were clustered, while all values - mean ages at death - are measured in the same units and standardized by the life table procedures. A straightforward clustering method was used – average linkage between groups.

The resulting cluster analysis dendrograms presented at Figure 83 and Figure 84 show that when mean age at death is used as classification criterion, independently on country or sex, five dissimilar and relatively coherent age-related groups of diseases appear:

- The first group is, as expected, formed by the *diseases of early infancy*.
- The second group comes out of the analysis clearly as well – it mainly gathers conditions related to risk behaviour (assault, traffic accidents) and HIV with its specific mortality pattern, the mean age oscillates around 45 years. Suicide is the “oldest” cause among these *accidents of young adulthood* with the overall mean age of 55 years.
- The third group of age-connected diseases consists mainly of cirrhosis, viral hepatitis, accidents, smoking related cancer, other cancer and bacterial diseases. In females, also breast cancer falls into this category. The overall mean ages for these causes lie between 67 and 70 years, which is the level of LEB attained by females

⁹¹ Using the program STATA

already in the 1950s and reached by the French and German males in the mid-1970s. From this aspect, the mortality from this cluster of diseases can be considered as *premature*. Interestingly, the list of diseases in this group suggests that a large part of premature mortality is purely man-made via extensive consumption of tobacco and alcohol.

- The overall mean ages at death from the following group of diseases fall between 73 and 77 years, covering the age groups near the LEB. These diseases can therefore be considered as *modal*, while concentrated around central measures of mortality. Most stable members of this central group are acute myocardial infarction, cancer of stomach and colorectal cancer. Residual diseases fall into this group, as well.
- The last group of diseases gathers close clusters of diseases with highest mean age at death, and almost unanimously, this category of *old-age diseases* contains influenza, pneumonia, chronic obstructive pulmonary disease, and, mainly, the heart disease complex, stroke and other circulatory diseases. In males, prostate pathologies (hyperplasia and adenocarcinoma) have been found to be the “oldest” diseases in the file.

Figure 83 Cluster dendrograms, males

Hierarchical cluster analysis dendrograms

Mean ages at death by cause

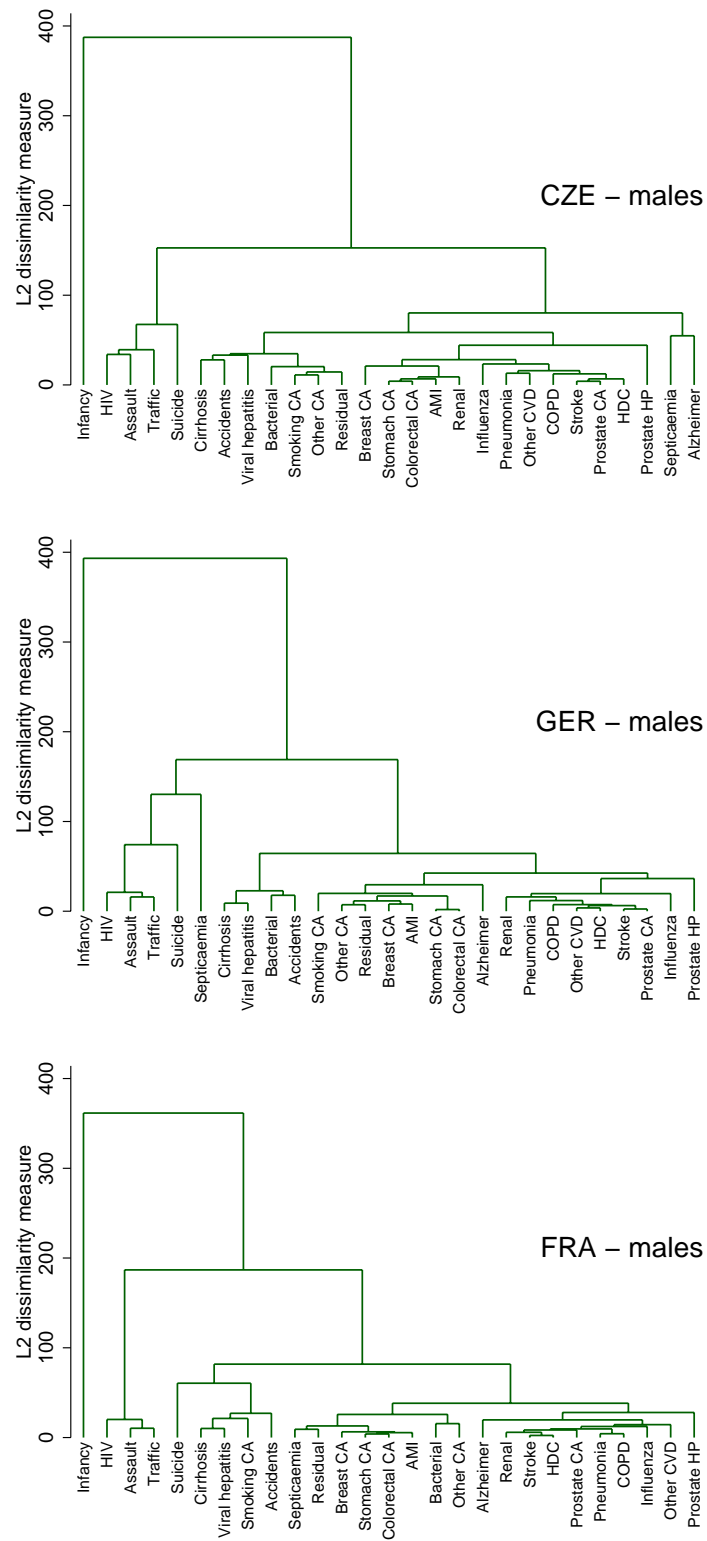
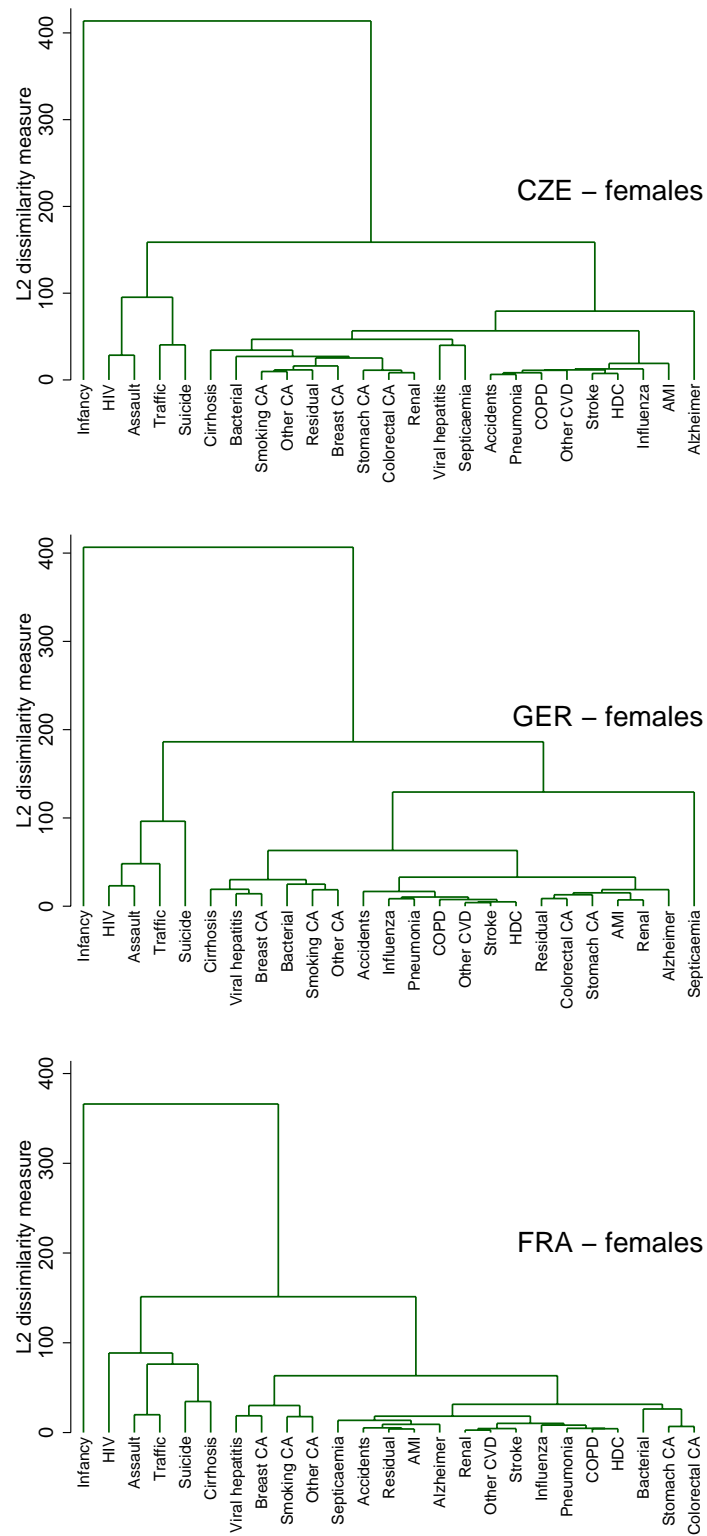


Figure 84 Cluster dendrograms, females

Hierarchical cluster analysis dendrograms

Mean ages at death by cause



Method: average linkage without Z score transformation

Table 38 combines the list of 27 selected groups of diseases with information about the mean age. The diseases are (approximately) sorted from “youngest” to “oldest” and alongside with each cause of death, a mean of mean ages at death computed for *all countries, both sexes and all periods combined* is displayed. Next column contains standard deviation of mean age at death from the given cause.

To avoid bias introduced by differentials in mortality levels over time and between countries, a non-parametric mean ranking was also applied: mean ages were ordered within each combination of country, year, and sex, and from these, mean rank and standard deviation were computed.

Table 38 Classifying diseases by mean age at death

Item	Title	186-list codes	Mean age	SD age	Mean rank	SD rank
001	Diseases of infancy	141-151	5.9	5.9	1	0.0
002	HIV	016	44.2	3.7	3	0.9
003	Assault	173-177	41.6	4.4	3	0.7
004	Traffic accidents	156-158	46.3	4.2	4	0.8
005	Suicide	168-172	55.7	3.0	5	0.5
006	Chronic liver disease and cirrhosis	122	64.1	2.7	7	1.9
007	Viral hepatitis	020	65.5	4.3	8	2.0
008	Septicaemia	013	67.4	14.1	11	4.9
009	Bacterial infection	001-012, 014-015	70.2	5.8	11	2.6
010	Accidents	159-164, 186	71.5	9.4	14	6.4
011	Smoking-related cancer	026-027, 034-035	69.5	2.5	10	2.2
012	Other cancer	031-033, 043-055	70.6	3.7	11	1.2
013	Breast cancer	038	70.1	3.0	11	3.7
014	Residual	REST	73.0	6.2	14	2.7
015	Stomach cancer	028	74.5	3.3	16	2.3
016	Colorectal cancer	029-030	74.1	3.3	15	2.0
017	Acute myocardial infarction	084-085	75.2	4.9	17	2.1
018	Alzheimer's disease	064	74.0	10.0	17	6.3
019	Renal diseases	128-134	76.7	5.1	19	2.8
020	Influenza	103	79.1	5.2	23	3.8
021	Pneumonia	104	79.4	5.0	23	2.7
022	Chronic obstructive pulmonary disease	105-109	79.2	4.3	23	2.4
023	Other circulatory disease	077-083, 095-100	78.6	4.3	22	2.2
024	Cerebrovascular disease	093-094	79.5	3.5	23	1.8
025	Heart disease complex	086-092	79.7	4.0	23	2.3
026	Prostate cancer	042	78.2	2.3	21	4.5
027	Hyperplasia of prostate	136	80.8	2.8	23	5.6

Big variability (measured by standard deviation of mean age or of mean rank) may thus result from radical change of mean age at death or from large inter-country/sex disparities. It can however also reflect irregularity and inconsistency in coding. In our file, the most of variability in mean age of death was observed for septicaemia, Alzheimer's disease and

accidents. For accidents, the source of variability is possibly attributable to higher mean age at death in females than in males (in females, accidents were clustered with “older” causes than in males. Septicaemia and Alzheimer’s disease then rather represent new or unstable medical entities. Note that also in the graphical representations of cluster analysis, these two diseases “float” among other causes, depending on their country-sex-specific age profile.

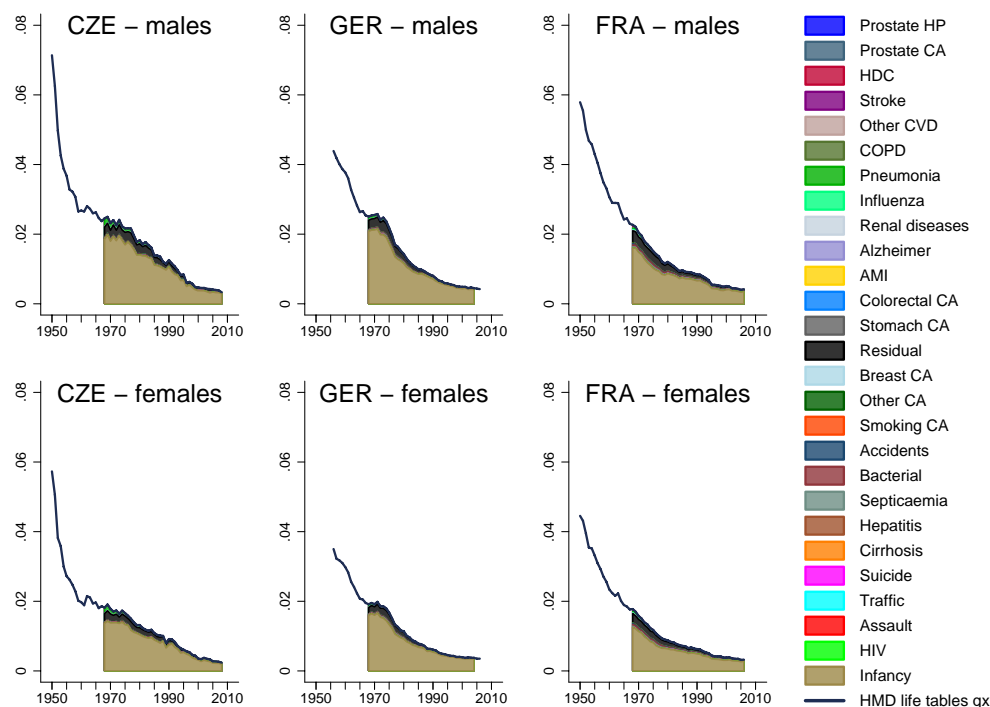
7.2.3 Age-specific probabilities by cause of death

As we opened the topic of interaction of age and cause specific mortality, it is worth looking more thoroughly at mortality profile by age. We selected 7 broad age groups: 0, 1-4, 5-29, 30-44, 45-59, 60-74, 75-84 and ages above 85. For these age groups abridged multiple decrement life tables were constructed. The indicators plotted in the following graphs represent the competing life table probabilities of death within the interval $[x, x+n)$, expressed as:

$$q_x^i = q_x \cdot \frac{D_x^i}{D_x}$$

For better perspective, the available cause-of-death data were connected to the all-cause q_x from the HMD master tables up to the 1950s.

Figure 85 Probability of death at age 0



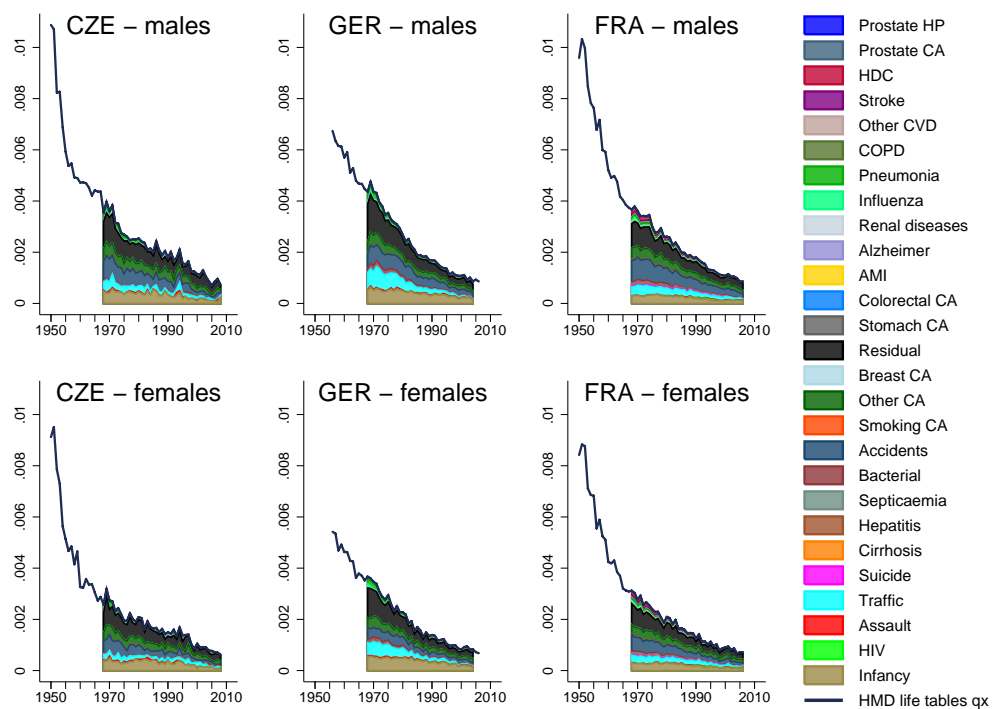
Infant and child mortality - secular decline

Infant mortality has decreased in all the three countries during the whole period of observation (Figure 85). The most remarkable was the decline of infant mortality observed in

the Czech Republic in the early 1950s, which also resulted in record age-specific contributions to life expectancy at birth.⁹² France and West Germany followed parallel trends. The Czech health care system managed to keep pace with the developed countries only until 1965. The two upcoming decades were marked by deceleration of infant mortality decline - the progress in reduction of infant deaths was resumed only in the 1980s. Since 2000 the progress in infant mortality has been very slow - the theoretical limit of infant mortality is possibly being approached. Concerning the cause of death, decisive part of infant mortality is due to the diseases of the ICD chapters of perinatal and congenital causes. More refined list is therefore needed for deeper study of infant mortality.

The post-war years were also beneficial for children aged 1 to 4 years - the decline in their mortality was as spectacular as that of infants (Figure 86). These major improvements were largely due to successful fight against infections, which started back in the pre-war era (at least this was the case in France, according to Vallin and Meslé (1988). Our data for period after 1968 explain the child mortality progress as a balanced decrease of mortality from traffic accidents, other accidents (typically accidental drowning) and other residual diseases.

Figure 86 Probability of death at age 1-4



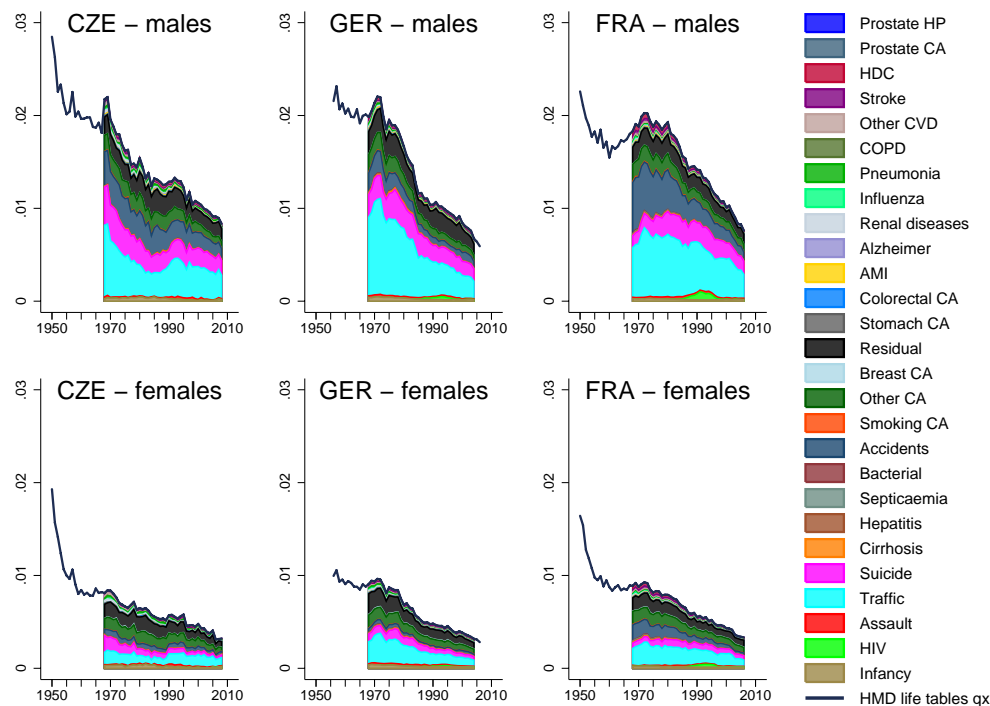
Mortality at young ages

Mortality of the young adults aged 5 to 29 results mainly from traffic, other accidents and suicides. Once again, the rapid mortality decline observed in the all-cause HMD data shortly after WWII, attributable to previous advances in curing infectious diseases is present in all the

⁹² This spectacular decline of the infant mortality in Czech Republic coincided with the implementation of a new health care system in 1948.

countries. Inter-country differences for this age group however remain minimal. The countries also experience similar patterns of remarkable mortality gap between the two sexes (Figure 87).

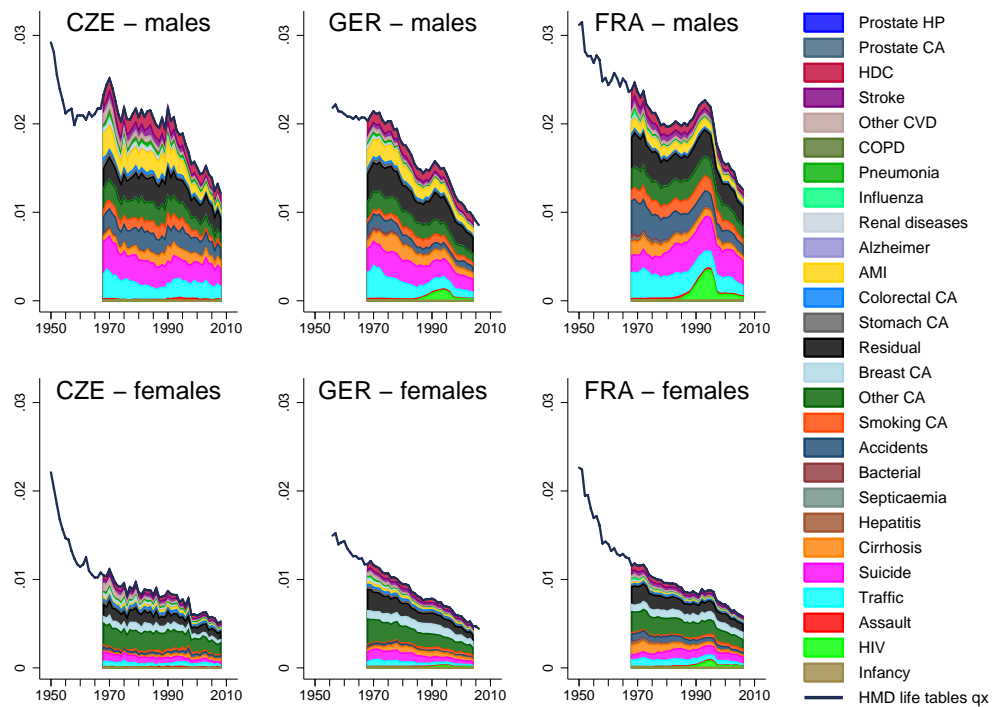
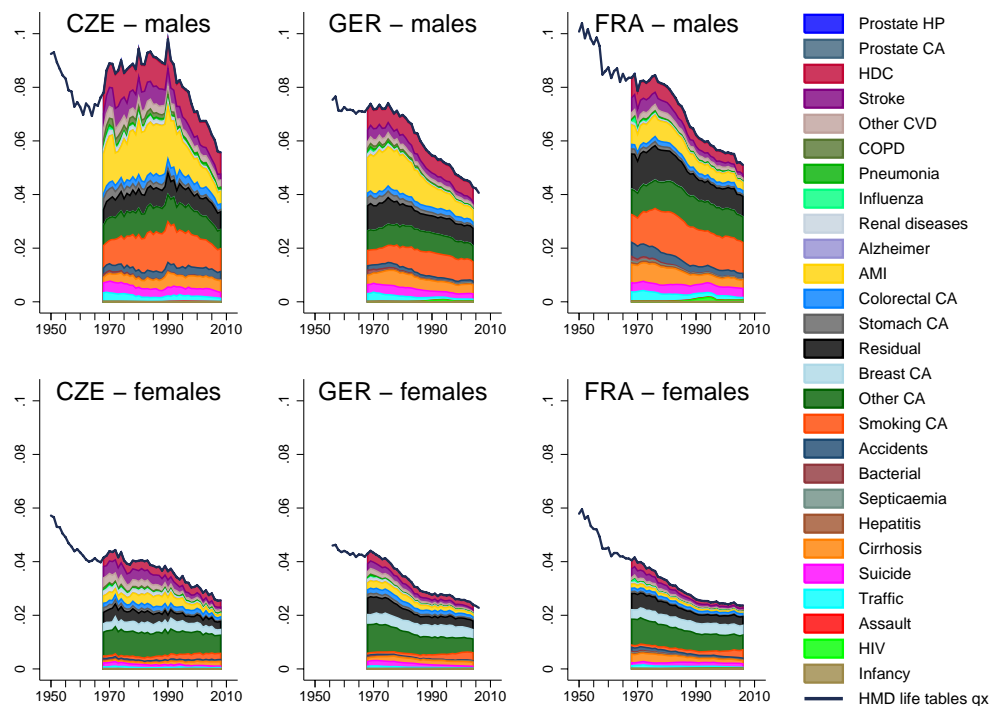
Figure 87 Probability of death between age 5-9 and 25-29



Adult mortality

According to Vallin and Meslé (1988), the mortality between ages 30 and 44 represents a transitional stage between those who die young and the majority dying later in life. The graphs comply with this characteristic: in all the three countries, the cause specific profile is a balanced mixture of accidental, residual and early cardiovascular mortality (Figure 88). The French adults were exceptionally highly affected by the epidemics of AIDS, which spread in the mid-1980s and which now is under control. At this stage of life (adulthood), a systematic inter-country gradient is still not present. As the only ones in the sample, the Czech adult males underwent worsening of survival in the 1960s (in the remaining countries only older age groups were affected) and a period of deceleration of the decline, present until the 1990. Relatively worse survival of the Czech males prior to the 1990 was mostly due do mortality from acute myocardial infarction, and other circulatory diseases, with contribution of increased mortality from suicide. The Czech females, in contrary, experienced the lowest mortality levels among the three countries due to lower levels of external mortality, lower residual mortality, and partially lower rates from breast cancer mortality.

Regarding the older adults, males aged 45-59 were fully hit by the health crisis of the 1960s in all the three countries – the male mortality stagnated in France and West Germany, and increased in the Czech Republic. In France and West Germany the trends reversed in the 1970s, but the worsening of Czech male survival lasted until 1990 (Figure 89).

Figure 88 Probability of death between age 30-34 and 40-44**Figure 89** Probability of death between age 45-49 and 55-59

This sustained increase in Czech male mortality observed between 1960 and 1990 can be mostly attributed to continuous increase of mortality from acute myocardial infarction and higher mortality from stroke, strengthened by increasing mortality from smoking-related cancer.

After 1990, these three causes of death were also responsible for most of the remarkable mortality turnover in older adults.

In West Germany reductions of acute cardiovascular mortality underlied the male mortality decreases twenty years since the 1970s and until today, the major advances are due to mortality from acute myocardial infarction. In France, the role of the AMI mortality is weaker, and the observed decline was more driven by mortality from cirrhosis and accidents.

Regarding the causes of death, this age group is fully exposed to the deleterious effects of unhealthy lifestyles - the highest proportions cirrhosis or smoking-related cancer are found. Smoking related cancer, cirrhosis and accidents are also the main contributors to relatively worse position of French males.

Females aged 45-59 also underwent smaller health crisis in the 1960s, but due to advances in cardiovascular and cancer mortality, the female survival in West Germany and France rapidly improved. Since 1990 the progress slowed down and most causes of death maintained constant levels and structures, while smoking-related cancer mortality started to increase in all the three countries.

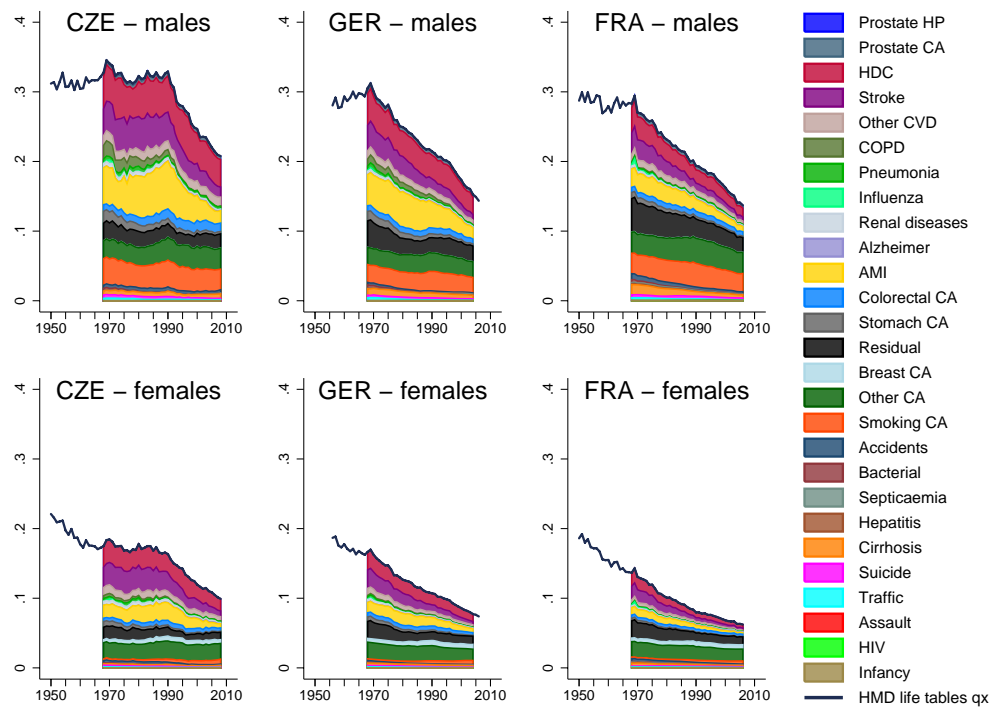
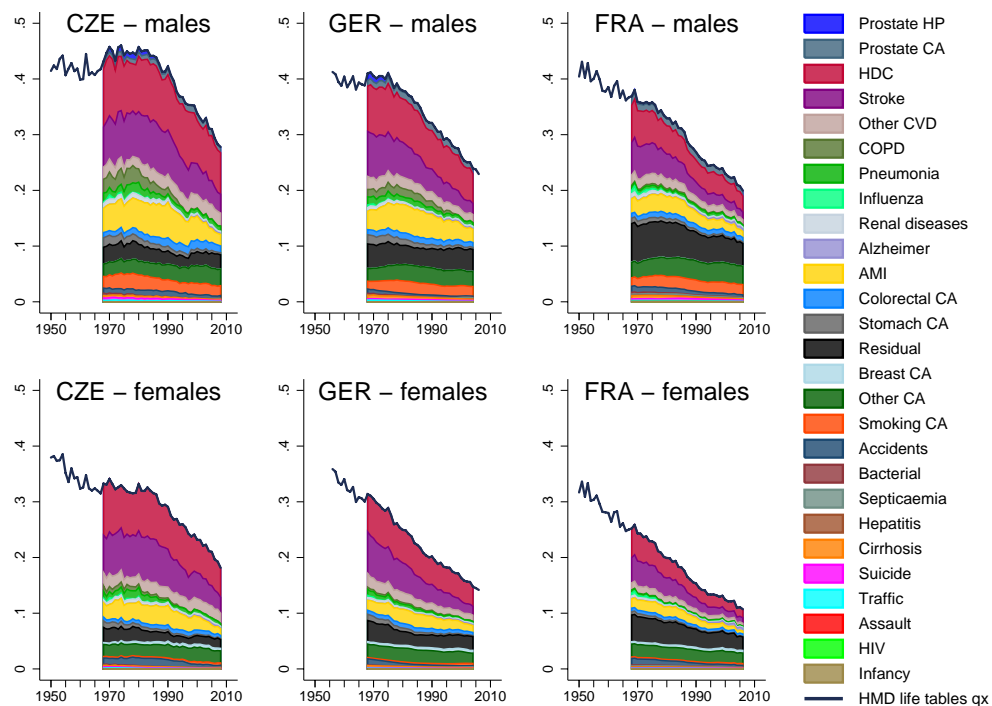
Unlike for males, the Czech female mortality at age 45-59 quickly recovered from the crisis of the 1960s, but the advances were hindered by stagnation of cardiovascular mortality until mid-1980s. Once again, breast cancer is less present than in West Germany and France.

Old age mortality

Compared to the previous age group, the probabilities in age group are 60-74 triple and a clear country gradient appears, with the Czech Republic in the worst position, West Germany intermediate and France as leading country, more evident in females (Figure 90). In West Germany and France, the year of availability of cause-specific data coincides with the onset of sustained mortality decrease in males. We see regular decrease of mortality from cirrhosis, acute myocardial infarction and stroke, while the heart disease complex and cancer tend to stable proportions.

In the Czech Republic, the trends set in the 1970 looked promising - mortality decline was comparable to that of other two countries. The improvement was short-lived - acute myocardial infarction and stroke then caused sustained stagnation of survival between until 1990. In the 1970s and 1980s remarkable improvements of chronic respiratory obstruction apeased the impact of the cardiovascular crisis. Meanwhile, colorectal cancer mortality continuously increased to reach the highest level among the three studied countries.

In females, the mortality trends in this age group depend on the advances in cardiovascular mortality. Prior to 1990s, the residual category of diseases also contributed to the mortality decline. Proportions of cancer are stable over time, and breast cancer is much less present at this age. On the Czech Republic, the trends were similar to those of males – signs of improvement in the 1970s and consequent stagnation until 1990 due to lack of progress against cardiovascular mortality.

Figure 90 Probability of death between age 60-64 and 70-74**Figure 91 Probability of death between age 75-79 and 80-84**

The older old (aged 75-84) have specific mortality profile characterized by prevailing heart diseases and stroke, and relatively low mortality from cancer (Figure 91). Other degenerative,

age-related or end-stage conditions such as COPD, prostate neoplasms and pneumonia are also more present.

The French males aged 75-84 passed the period of observation without dramatic reversal of favourable decline driven by cerebrovascular mortality, and, to a lesser extent, decrease in acute myocardial infarction. Short-term stagnation was observed in the early 1970s, but since the mid-1970s the mortality decrease was fluent with slight acceleration in the 1980s due to rapid decrease in stroke mortality. Regarding myocardial infarction, we note at this point that while the French mortality from heart diseases and stroke is mostly comparable to the other two countries, the mortality from acute myocardial infarction is systematically lower. At the same time, as acute myocardial deaths emerge, let us say after 45 years of age, the low mortality from AMI is accompanied by high mortality from the residual category in both sexes, and it is possible that these two categories are connected.

West German males went through similar process, with similar underlying decline in stroke and AMI mortality and similar timing, i.e. temporary stagnation and consequent recovery in the mid-1970s.

In the Czech population, like for younger age groups, the excess of mortality was caused by AMI, stroke and heart diseases, and in the first half of the period of observation reinforced by elevated COPD and prostate hyperplasia mortality. Same as for younger old, the colorectal cancer represents an increasing health threat. Concerning the timing, the group experienced worsening and consecutive stagnation of all-cause mortality, but unlike for younger age groups this unfavourable trend was reversed earlier – in the mid-1980s – due to rapid advances in COPD and stroke mortality and gradual decline in AMI.

Female profile of the older-old category can be seen as a “smaller version” of the male one – at this age, the gender differences in cause specific mortality *structure* virtually disappear (with exception of absence of smoking-related cancer in females and, of course, sex-exclusive diseases). During the critical decade of the 1970s, stagnation was less pronounced in French and German females due to absence of the “cardiovascular crisis”. The Czech female mortality copied the male one, by both structure and timing.

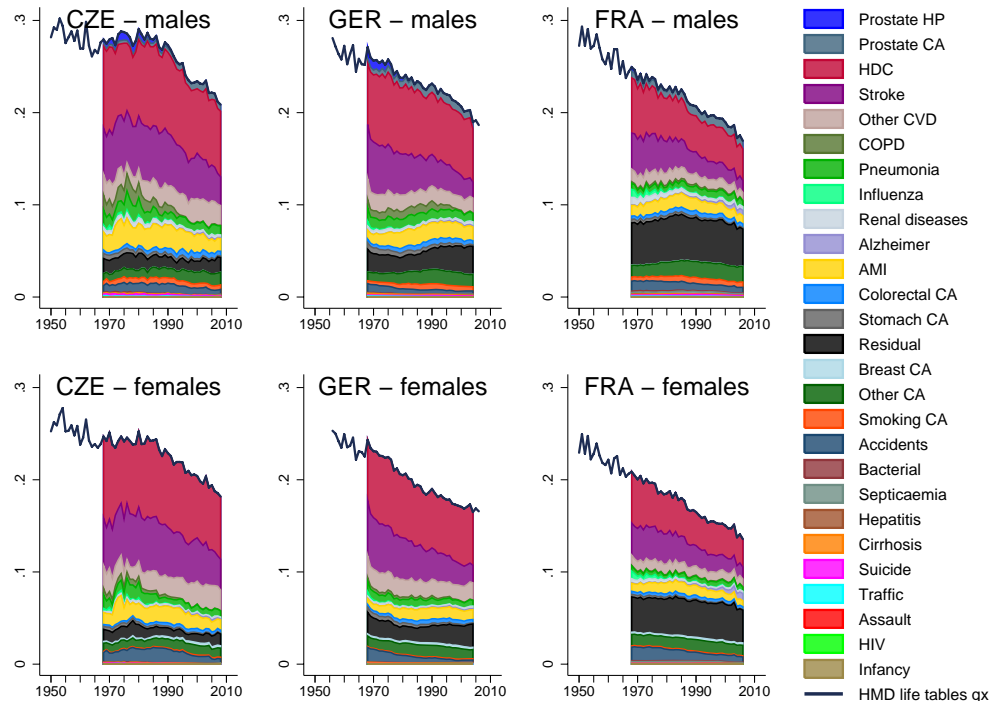
Lack of information for the oldest old

The cause-specific data are often limited by the lack of detail for the oldest old. It is common that the published data end at age 85+. Our data have cause-specific detail until 90+ for West Germany and until 100+ for France, but due to inclusion of the Czech Republic in the analysis, the upper interval was cut to 85+. If death probability was plotted, the result would only provide structural aspect. We decided therefore to add the only available information about the size of mortality in the open age interval – the mortality rate, and decomposed it using the same rule of proportionality, i.e.:

$$M_{85+} = \sum_i M_{85+} \cdot \left(\frac{D_{85+}^i}{D_{85+}} \right)$$

An indicator conceived this way is of course influenced by differences in the age structure after age 85, and in a deeper study a method of indirect standardization with French cause-specific mortality until age 105+ as standard could be used for mutual comparisons.

Figure 92 Death rate after age 85 by cause



The crude information presented on the graphs suggests the overall mortality after age 85 follows similar trends as the previous age group, with higher prevalence of chronic heart diseases and stroke. Mortality from AMI and cancer is very low, while elevated presence of accidents, especially in elderly females, is due to accidental falls. The advances in France and West Germany were mainly due to declining stroke mortality and hindered by the residual category of diseases. The cause of death pattern is more homogeneous in the Czech Republic, where majority of all deaths occurring after age 85 are attributed to circulatory diseases.

7.2.4 Interactions between causes of death, age and life expectancy

As was shown in section 7.2.1, life expectancy at birth can also be viewed as an average of cause-specific mean ages at death weighted by the shares of life table newborns eventually dying from cause i . To see how these two cause-specific components interact with LEB, we produce bar plots with variable bar width representing the weights, and bar height representing the mean ages of death by cause. Three periods were selected – the first year, the year before the fall of communism, and last year of common available COD data – 2004. Data plotted in Figure 93 and Figure 94 are presented in Table 39 and Table 40. The figures decompose the life expectancy at birth into the qualitative (age) and quantitative (share) factor: life expectancy at birth moves as combination of both. Applying approximate ordering of causes by age adds another angle of view: life expectancy is “pushed down” by premature diseases on the left side, and “pulled up” by diseases of old-age on the right side of the graphs.

Table 39 Multiple decrement life tables results, males

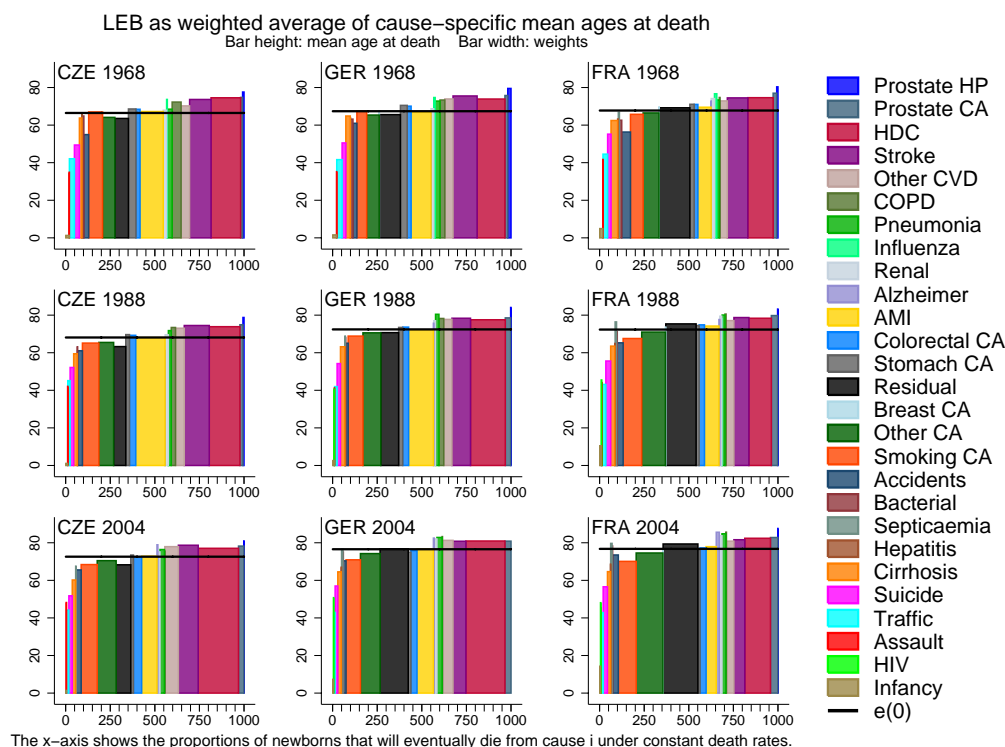
Cause	Title	1968						1988						2004					
		CZE		GER		FRA		CZE		GER		FRA		CZE		GER		FRA	
		e ₀	Share	e ₀	Share	e ₀	Share	e ₀	Share	e ₀	Share	e ₀	Share	e ₀	Share	e ₀	Share	e ₀	Share
	All-cause	66,46		67,40		67,72		68,11		72,41		72,33		72,59		76,56		76,75	
001	Infancy	1,3	1968	1,6	2225	4,9	1787	1,1	1093	2,6	887	10,5	883	1,4	343	7,3	499	14,3	499
002	HIV	.	0	.	0	.	0	.	0	40,6	130	45,5	356	.	0	50,8	81	48,1	193
003	Assault	34,9	93	35,2	83	41,7	91	42,1	64	41,3	82	44,1	120	48,2	115	42,4	49	45,5	79
004	Traffic	42,1	2801	41,6	3036	44,5	2581	45,1	1349	42,0	1437	43,1	2184	44,2	1384	42,9	724	42,8	1199
005	Suicide	49,4	2838	50,5	2044	55,2	1917	52,1	1964	54,2	1875	55,6	2635	51,8	1853	57,0	1558	56,6	2422
006	Cirrhosis	63,8	1402	64,8	2474	62,4	3709	59,4	1985	63,2	2394	63,5	2313	60,2	1897	64,5	1914	64,6	1723
007	Hepatitis	66,5	74	63,9	115	63,0	307	65,9	38	63,1	139	64,9	194	62,5	21	67,0	134	68,6	131
008	Septicaemia	49,6	16	34,2	34	66,8	628	65,0	32	68,8	167	76,4	814	67,5	189	76,5	833	79,7	783
009	Bacterial	64,8	995	63,2	1346	62,6	1324	63,2	207	68,1	237	71,2	422	65,6	96	75,1	166	78,3	298
010	Accidents	54,9	2719	61,0	2216	56,3	4912	61,0	2709	65,1	1330	65,3	3307	65,5	2832	70,4	1531	73,5	3162
011	Smoking-CA	67,0	7806	67,3	5499	65,7	7036	65,1	9114	68,8	8307	67,6	10401	68,4	8922	70,9	8094	70,1	10031
012	Other CA	64,1	6884	65,3	7055	66,5	8927	65,5	8339	70,6	10025	71,0	13285	70,5	10626	74,2	10974	74,6	14960
013	Breast CA	65,5	13	67,6	25	69,7	109	69,9	28	70,1	26	73,6	138	68,0	24	75,4	47	76,1	80
014	Residual	63,5	7628	65,6	11844	69,2	17156	63,3	6764	70,7	9983	75,3	17070	68,3	8247	76,8	15804	79,3	19508
015	Stomach CA	68,6	4186	70,5	3789	71,1	2434	69,6	2131	73,5	2325	74,5	1662	73,4	1479	75,0	1458	76,0	1192
016	Colorect. CA	68,4	2323	70,1	2219	71,0	2114	69,3	3455	73,6	3237	74,8	3002	72,5	4617	75,8	3386	77,2	3434
017	AMI	67,2	12913	67,0	11099	69,5	7351	68,1	16443	72,2	13908	74,2	8143	72,8	8532	76,6	9217	77,9	5677
018	Alzheimer	62,0	12	66,4	62	72,8	151	61,2	94	75,7	231	77,6	516	78,9	532	82,5	542	85,6	1760
019	Renal	67,9	1899	68,7	1554	74,1	1755	69,5	1720	77,0	958	79,4	1072	75,1	1168	82,0	1484	83,7	1421
020	Influenza	73,7	419	74,7	813	76,7	1337	68,3	48	73,0	27	78,2	163	79,6	12	78,2	17	83,2	23
021	Pneumonia	68,5	2721	72,8	2622	73,4	1417	71,8	1655	80,5	1921	80,0	1656	76,4	2470	82,8	2873	84,8	2185
022	COPD	72,2	5005	73,3	2788	74,7	430	73,4	2365	78,2	2671	80,6	593	75,7	261	83,3	185	85,6	302
023	Other CVD	70,2	4765	73,9	4570	72,9	4073	73,0	4908	77,7	4555	77,1	4377	77,9	7572	81,3	5937	80,9	4206
024	Stroke	73,6	12019	75,5	13467	74,5	11437	74,5	14042	78,4	10445	78,7	8371	78,7	11066	80,8	7236	81,6	6161
025	HDC	74,5	16576	73,9	15651	74,6	14206	73,9	17180	77,5	19536	78,3	12665	77,0	22682	80,9	21889	82,4	14372
026	Prostate CA	74,7	1139	75,7	1567	77,0	2058	74,9	1634	78,5	3015	79,8	3486	78,2	3000	80,9	3336	82,8	4110
027	Prostate HP	77,6	786	79,5	1805	80,3	682	78,7	636	84,1	152	83,2	173	81,0	60	86,0	29	87,6	89

Cause	Title	1968						1988						2004					
		CZE		GER		FRA		CZE		GER		FRA		CZE		GER		FRA	
		e ₀	Share	e ₀	Share	e ₀	Share	e ₀	Share	e ₀	Share	e ₀	Share	e ₀	Share	e ₀	Share	e ₀	Share
	All-cause	73,38		73,44		75,19		75,36		78,93		80,48		79,23		81,91		83,86	
001	Infancy	1,2	1459	1,9	1731	6,8	1444	0,7	908	3,7	658	15,0	686	0,8	284	7,2	417	18,2	422
002	HIV	.	0	.	0	.	0	.	0	39,0	11	40,0	88	.	0	42,0	20	46,8	61
003	Assault	33,2	75	32,4	68	43,6	57	37,7	56	39,8	83	48,5	78	44,1	60	43,5	45	51,8	58
004	Traffic	53,4	911	46,6	1051	48,8	978	55,7	540	49,4	613	51,6	913	48,7	509	47,2	258	51,0	421
005	Suicide	55,5	1392	54,7	1079	57,1	750	59,0	920	58,5	848	59,4	1101	59,2	449	61,6	544	57,9	891
006	Cirrhosis	70,1	761	69,9	1374	61,3	1686	67,7	800	66,5	1228	64,4	1111	63,1	809	67,5	980	66,3	724
007	Viral hepatitis	64,7	53	67,2	72	63,5	176	66,9	31	66,2	74	68,7	109	73,9	10	74,4	136	76,9	124
008	Septicaemia	60,1	19	43,1	34	73,4	687	70,1	63	74,4	191	82,5	972	77,5	150	79,9	839	84,2	822
009	Bacterial	71,6	632	65,2	522	67,4	748	71,0	174	71,2	144	79,1	434	59,6	83	80,7	174	84,7	348
010	Accidents	75,6	2935	79,2	3313	75,8	5079	80,0	4223	82,2	1809	81,9	4434	81,0	3042	81,2	1413	85,6	3798
011	Smoking-CA	70,4	1055	70,2	935	72,5	1169	68,2	1435	71,7	1712	73,9	1664	70,8	2470	71,4	2860	72,5	2431
012	Other CA	67,8	9360	68,1	10492	70,5	11021	69,0	10442	74,2	12156	75,7	12756	73,4	12049	76,6	11019	78,7	13267
013	Breast CA	65,3	1982	66,0	2455	68,2	2573	67,4	2837	69,2	3746	71,1	3591	72,6	3323	72,2	3759	73,8	3992
014	Residual	69,2	8725	70,9	12798	75,9	18176	70,2	6485	77,6	10384	82,5	20700	75,4	7190	82,1	15652	85,8	23581
015	Stomach CA	72,6	3389	74,8	3222	76,2	2018	73,5	1579	77,7	1924	80,4	1243	76,1	1048	78,5	1112	81,4	745
016	Colorectal	71,5	2084	72,2	2465	75,2	2402	72,5	3183	77,1	3643	78,9	3004	76,3	3385	79,4	3146	81,4	3097
017	AMI	74,7	7645	73,6	5668	77,1	5643	75,5	11101	79,2	9163	82,6	7358	79,8	6601	82,9	6914	86,4	4867
018	Alzheimer	75,2	2	70,3	71	78,6	199	66,8	119	77,3	311	82,7	737	81,0	917	84,7	746	88,6	3931
019	Renal	68,0	2049	70,8	1759	77,8	1777	73,0	1822	80,0	1110	83,8	1135	78,2	1385	84,6	1474	86,9	1447
020	Influenza	80,5	693	78,9	1151	82,4	2278	78,2	80	83,0	45	85,2	303	83,7	28	85,0	21	88,6	49
021	Pneumonia	76,0	3473	77,2	3045	80,0	1778	78,2	2109	84,9	2125	85,8	1925	81,8	2304	86,1	2813	8	

Male life expectancy at birth in France and West Germany underwent gradual decline of the quantitative component of AMI and stroke mortality, and today's newborns surviving up to the age of all-cause LEB have much more chances to rather die of some of the chronic heart diseases of old age. The competing nature of multiple decrement processes implies that if probability of exiting from one cause declines, the probability of existing from other causes must increase. At older ages, this competition is seen in receding stroke mortality being replaced by the complex of heart diseases, while decline of AMI mortality at younger ages leaves space for relative increases of colorectal, smoking related and other premature cancer mortality. Regarding the age component, the mean age at death for majority of the causes considerably increased; most remarkable were the advances in respiratory diseases – deaths from COPD and pneumonia now take place 10 years later in life than by the late 1960s. Little less pronounced was the aging of the major circulatory diseases – their victims recently are on average 7-8 years older compared to 1968. The AMI keeps the position of the youngest cardiovascular disease, but its average onset is at age 78 years in France and 77 in West Germany, compared to 69 and 67 in 1968, resp. The least improvement in age structure was found in cirrhosis, accidents, and smoking related cancer.

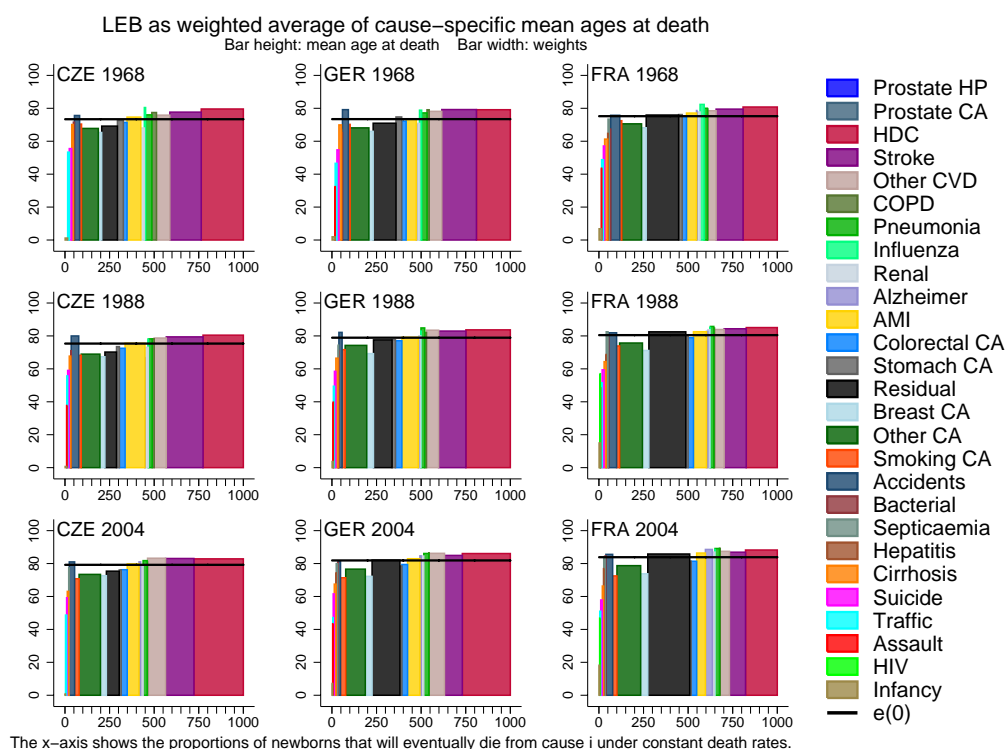
Very little progress was observed in the Czech Republic during the whole period of 1968-1988: the chances of dying from acute myocardial infarction and stroke increased and mean ages at death stagnated or even decreased in case of smoking-related cancer and heart disease complex (from 67 to 65 years and 74.5 to 73.9 between 1968 and 1988, respectively). In 2004, the structure of cause-specific chances of death is similar to that observed in West Germany, and most of the 4 years of difference between Czech and German male life expectancy can therefore be attributed to persisting younger age structure of virtually all the selected diseases.

Figure 93 Qualitative and quantitative components of LEB, males



The chances of newborn females are, with respect to the cause of their death, more straightforward: in half of the case they will eventually die from one of the chronic diseases of old age or – unlike for males –, from accident at old age, and compared to females in 1968, more probably from heart disease than from stroke or AMI. Among women who die prematurely and non-accidentally, cancer of breast and smoking related cancer chooses the youngest victims, but the most of the risk of premature death is due to the category of “other cancer”. As for males, chances of dying from stomach cancer and AMI decreased, but were compensated by increasing weight of colorectal cancer. Compared to males, the structure of risk of death in females is more stable in time and its age structure is more tightly distributed around life expectancy at birth. Major structural shifts were found only within the circulatory diseases of old age, where reductions in cerebrovascular mortality are continuously replaced by increasing chances of death from heart disease occurring on average 1 year later in life. French female population is also the first to show visible impact of increasing mortality from Alzheimer’s disease on the life expectancy at death.

Figure 94 Qualitative and quantitative components of LEB, females



In both sexes, major structural differences between countries consist in different risks of dying from the residual category of diseases. There is a clear country gradient for both the risk size and the mean age of these residual deaths: the highest risks at oldest age are always found in France, closely followed by West Germany, while in the Czech Republic the respective proportions are minimal and the mean age at death from this category is 4-5 years lower than the overall Czech LEB and recently 10-11 years lower than in France, currently representing the biggest age disparity between the Czech Republic and the two remaining countries.

It should be stressed once again here, that multiple decrement process relates to probabilities, and that these probabilities depend one on another – there cannot be a decrease in

one cause without compensating increase from other cause. This does not apply to rates, which relate to person-years of exposure, and where a decrease of *rate* for one cause is – at least theoretically – independent from other causes.

In France and West Germany, major advances of mortality are unanimously attributable to the long-term decline of mortality from cardiovascular diseases. In the universe of probabilistic multiple decrement model, there has to be a compensation for these declines. For two major reasons, the competition between cardiovascular mortality and second leading group of causes of death – cancer – is not sufficient: cancer operates at much younger ages and the observed increase of the cancer risk is not proportional to the cardiovascular advances.

In these terms, the residual category suits the criteria for the main compensatory target: its share is negatively correlated with CVD, while the mean age at death correlates positively. In the Czech Republic, a process analogous to cardiovascular revolution has begun in the 1990s and brought unprecedented declines in cardiovascular mortality, which can be viewed as a condensed version of the cardiovascular revolution in the West.

According to Rychtaříková (Rychtaříková 2004), major underlying factor of these changes were, rather than changes in life styles, increased availability of pharmacological and non-invasive life-saving cardio-surgical treatment. The multiple-decrement approach adds another support for this thesis: the decreases in cardiovascular mortality observed in the Czech Republic after 1990 had no impact on any other conditions outside of the chapter of cardiovascular diseases, and increases in life expectancy thus purely resulted from postponing of cardiovascular deaths to chronic stages of the same pathological process; the real qualitative change in mortality is still yet to come.

Summary of findings, broader context and perspectives

The main part of the study dealt with the methodology of reconstructing the time series, focusing on specific problems of the ex-post double classification and the question of the medical content of the ICD categories. All stages of reconstruction work were described and accompanied by practical examples of problems encountered and solutions applied. Some causes of death required special treatment due to the change in coding instructions. This happens more frequently shortly after introducing a new classification, while in rarer cases corrections are needed when a new disease is introduced, as was the case of AIDS in West Germany. Thus, although the principles of the method can be applied universally (including countries not using ICD), the specific problems will vary from country to country due to persisting variance in reporting and coding practices. Obviously, such problems can be detected solely by systematic inspection of the time series on a detailed level.

The presented work has several novel features. At the methodological level, for the first time the 3-digit ICD detail was – successfully – applied to West German and Czech data covering the 8th and 9th ICD revision. In earlier studies, the authors used either grouped items (Netherlands), or the most detailed 4-digit level (France), or the transition was performed on a classification other than ICD (countries of ex-USSR). As the 3-digit level is the usual level of detail provided by the national statistical offices (and the detail compulsory for reporting to the WHO), the results of this work could serve as a guideline for future reconstruction attempts in other countries where the double codification between ICD8 and ICD9 is missing.

As countries pass to ICD10, the risk of breaks in continuity is severe. In our selection of countries, France was the most affected because along with ICD10 an automated coding system was implemented. In West Germany the system adapted to new ICD10 rules rather gradually, while in the Czech Republic a data quality programme was organised to improve compliance to WHO rules in 2006 and the real impact of ICD10 became visible only 14 years after its adoption. Due to the amount of change and diverse effect of ICD10 on mortality coding across countries, it is very unlikely that a universal tool in a form of abridged list can be developed. In

contrary – the transition to ICD10 requires much more detail and complementary information than the transition between ICD8 and ICD9. For our purpose we proposed and applied a combination of abridged list of 186 items and of ex-post corrections of known issues. Nevertheless, for external causes of mortality the transition without information from bridge-coding is difficult.

The 186 items reconstructed over three ICD revisions covering almost four decades in time were thoroughly examined in chapter V via cause-specific standardized death rates. In majority of cases, the reconstructed data provide a reliable, coherent and directly comparable source of detailed information about the populations' health. Major issue has been identified for cardiovascular diseases, which is due to the complex nature and linked relationships between individual items of the circulatory diseases chapter. Genitourinary diseases have also been found difficult to compare, possibly due to different coding habits.

During the inspection of the standardized death rates by cause, an abridged analytical list was compiled with respect to capture the most of information on causes of death leading to divergence between countries, sexes or periods, and, at the same time, to eliminate the unwanted impact of comparability problems.

These causes of death then served as decrements in multiple decrement life tables. At first, life expectancy at birth by cause (of those eventually dying from the cause) was calculated and used as classification criterion in hierarchical cluster analysis. Quite consistent relations between age and diseases were found across the studied populations. In compliance with this finding, during examination of age-cause-specific probabilities different profiles were also found for the studied age groups.

To assess interaction between causes of death and life expectancy at birth, the latter was decomposed into its qualitative and quantitative component – the qualitative components were cause-specific mean ages at death, and quantitative components stood for the “shares of newborns eventually dying from the given cause”, the usual output of multiple decrement life tables. Important divergences were found in both components of life expectancy at birth especially in the middle of the studied period, which was marked by previous two decades of mortality stagnation in the Czech Republic. With time the cause-specific structural differences tend to diminish and differences in life expectancy are more due to the differences in mean age at death (which is currently consistently lower in Czech Republic for virtually all the selected diseases).

In a probabilistic life table, as cardiovascular mortality decreases, it is replaced by increasing probabilities of death from other causes. Our data showed that both in France and in West Germany, the saved cardiovascular deaths increased probabilities of dying from residual category of diseases, which until then stood apart from our attention. This finding thus opens interest in a deeper study on the nature of diseases which take place of the receding cardiovascular mortality. As was seen in the chapter investigating trends in standardized death rates for all the 186 reconstructed items, these diseases are spread across various chapters of ICD, hidden from the first attention of demographers. With continuing decreases of cardiovascular mortality, these diseases will form a new and more heterogeneous cause-specific profile, and should be therefore more present in demographic analyses.

Carefully reconstructed cause-of-death data offer exceptionally robust time series: the trends move gradually in time and under favourable socioeconomic conditions tend to create similar epidemiological profiles. This could be seen the most in the case of circulatory mortality, where West Germany followed a delayed pattern observed previously in France. The present situation in the Czech Republic represents a specific case: the speed of the recent circulatory mortality decrease was unprecedented, but these remarkable decreases were largely driven by the means of modern medicine. For further progress, more individual responsibility in adopting healthier habits will be needed.

Although our analysis was still more exploratory than explanatory, it enabled to demonstrate the increase of analytical information that can be gained by including detailed and reliable long-term cause-specific data. The future perspectives thus include, first of all, a deeper study of the database of the reconstructed 186 causes of death and eventually creation of an improved version of analytical list, which would reveal more information about the emerging post-cardiovascular profiles.

Another possible perspective is extending the series into the past. Our data start at the moment where divergences had already been present and we thus miss the moment of the divergence onset. This onset - a cross-over in trends between Czech Republic and France was observed in the 1960s for cerebrovascular mortality (Rychtaříková et al. 1989).

For West Germany, future addition of reconstructed series for East Germany will allow us to study what could be called a “natural experiment” – the separation and subsequent reunification of Germany. In demographic terms, the experiment lies in the unique chance to observe the impact of two different socio-political environments on one population and to analyse the factors behind the plasticity of mortality observed in East Germany shortly after unification.

West and East Germany were separated between 1949 and 1989. Until the early 1970s, mortality in both countries followed similar levels and trends (Gjonça et al. 2000). Later on, an East-West gap began to emerge, resulting in a difference of 2.6 years of life expectancy at birth for women and 2.4 years of difference for males just before reunification in 1989. Up to 2006, this difference was rapidly reduced to less than 1 year for females and to 1.2 years for males.

Studies addressing the widening and subsequent narrowing of the east-west mortality gap in Germany either worked on all-cause mortality (Gjonça et al. 2000), or aggregated the diseases into broad categories (Nolte et al. 2000). A large part of the gap has been explained as due to differences in medical care and public health, but this hypothesis has never been tested on detailed cause-of-death data in a longer term perspective.

The reconstruction of continuous series for West Germany and Czech Republic also opens the door to international comparisons with countries for which similar work has already been done (like France, Russia, Ukraine, Baltic countries, Netherlands etc.) or where bridge coding is available (like England and Wales, the United States, or Canada).

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Annex

Due to the excessive size, Annex for this thesis can be found at the attached CD-ROM.

It contains:

1. Associations between ICD8 and ICD9 for West Germany
2. Transition coefficients between ICD8 and ICD9 for West Germany
3. Associations between ICD8 and ICD9 for the Czech Republic
4. Transition coefficients between ICD8 and ICD9 for the Czech Republic
5. The 186-shortlist with correspondences for ICD9 and ICD10
6. Standardized death rates for the reconstructed 186 items
7. HMD life tables for the Czech Republic, West Germany and France (corrected for the Czech Republic for period 1953-1964)
8. Contributions to the change in LEB between periods 1950, 1960, 1971, 1980, 1990, 2000 and 2006
9. WHO standard population
10. Age structure of Czech Republic, West Germany and France
11. Standardized death rates for the 27 selected causes of death
12. Multiple-decrement life tables for the 27 selected causes of death