RECONSTRUCTION OF THE CONTINUITY OF CAUSE-SPECIFIC MORTALITY TRENDS FOR THE REPUBLIC OF MOLDOVA

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The paper presents the stages of reconstruction of the continuity of cause-of-death time series for Moldova based on a special method developed by French demographers Jacques Vallin and France Meslé (Institut national d'études démographiques, INED). The method eliminates the disruptions in death time series provoked by periodic changes in the classification and was successfully used in a number of industrialized countries. For the Republic of Moldova we reconstructed death time series by sex and age according to the short list of the 10th Revision of the International Classification of diseases and Causes of Death for the 1965-2012 period.

***Key words**: mortality, causes of death, method of reconstruction, International Classification of Diseases and Causes of Death, Republic of Moldova.*

În articol sunt prezentate particularităţile de ajustare a metodei de reconstituire a seriilor mortalităţii pe cauze de deces (elaborate de către demografii francezi Jacques Vallin and France Meslé, Institut national d'études démographiques, INED) la datele pentru Republica Moldova. Această metodă asigură continuitatea seriilor de timp ale deceselor pe cauze întreruptă de schimbările periodice ale clasificării şi a fost aplicată cu succes de către un şir de ţări dezvoltate. În urma studiului, au fost reconstituite seriile de timp ale deceselor pentru Republica Moldova pe sexe şi vârste conform listei scurte a Reviziei a X-ea a Clasificării Internaţionale a Maladiilor şi a Cauzelor de Deces pentru perioada 1965-2012.

***Cuvinte cheie:** mortalitate, cauze de deces, metoda de reconstituire, Clasificarea Internaţională a Maladiilor şi a Cauzelor de Deces, Republica Moldova.*

В работе представлены этапы восстановления непрерывности временных рядов чисел смертей для Республики Молдова на основе метода, разработанном французскими демографами Франс Меле и Жак Валлен (Национальный институт демографических исследований, ИНЕД). Данный метод устраняет разрывы временных рядов чисел смертей, вызванные периодическими пересмотрами классификаций причин смерти, и с успехом был адаптирован для ряда стран. Для Республики Молдова получены однородные временные ряды чисел умерших по полу и возрасту согласно краткому перечню 10-го пересмотра Международной классификации заболеваний и причин смерти за 1965-2012 годы.

***Ключевые слова:** смертность, причины смерти, метод восстановления, Международная классификация заболеваний и причин смерти, Республика Молдова.*

JEL Classification: I10; I19; J19; N3.

Introduction. In all countries, the analysis of long-term mortality trends by causes of death is complicated by ruptures in statistical series induced by the periodic revisions of the classification. In very rare cases, responsible statistical offices practice a double classification of causes of death for one or two transition years. This gives a possibility to use the observed transition coefficients to redistribute deaths classified according to the items of an old classification among the items of a new one. However, in most cases, including for the post-soviet countries, such double classification is not available and it is necessary to find a way to estimate the transition coefficients *ex post*. Such a method was developed for France to reconstruct cause-of-death time series classified according to the detailed ICD-9 list since 1925 (Meslé and Vallin, 1996). Then, this method was successfully used to reconstruct cause-of-death time series for different

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countries: the Soviet Union for the period 1970-1987 (Meslé, Shkolnikov and Vallin, 1992), Russia (Meslé et al., 1996), Ukraine (Meslé and Vallin, 2003, 2012), the Baltic countries (Jasilionis et al., 2011), Belarus (Grigoriev, 2012; Grigoriev, Meslé and Vallin, 2012), Armenia and Georgia (Duthé et al., 2010), Czech Republic and Western Germany (Pechholdová, 2009, 2010), Poland (Fihel, 2011) and other countries.

For Moldova, based on the reconstruction method we produced the 1965-2012 cause-of-death time series by sex and 5-year age groups and an abridged ICD-10 list that covers about two hundred items. Let us specify the main steps of the reconstruction method through the examples of matching the 1970 Classification and the 1981 Classification, and then, we shall briefly describe some peculiarities encountered for other transitions.

1. The method of reconstruction

The reconstruction method for each transition from an old classification to a new classification includes three main stages: constructing correspondence tables, defining fundamental associations of items, and calculating transition coefficients.

Correspondence tables

First, two symmetric tables that show correspondences between the old and the new classifications must be produced. One table lists, for each item in the old classification, all the items in the new classification that have one or more conditions in common with it. The other table lists, for each item in the new classification, all the items in the old classification that have elements in common with it. The second table is easily produced based on the first table by sorting the new items in ascending order. Obviously, with regard to the successive revisions of the soviet classification of causes of death, this step remains the same for all the former soviet republics. At this stage, only the medical content of the cause-of-death items is taken into consideration. Within the framework of theoretical definitions of items, the new classification did not introduce substantial changes to the old classification. One item of the 1965 Classification corresponds, as a rule, has no more than two or three items with the same medical content from the 1970 Classification, and conversely.

Fundamental associations of items

The correspondence tables are then used to define *fundamental associations of items* that include the items for all the conditions contained within the association to be identical at both revisions. At first, the fundamental associations are established based on the medical definition of items, i.e. based on the correspondence tables. Each association contains the following information: title and code of the items under the new and old classifications, the corresponding death counts observed in a transition year and a year before the new classification was adopted, and the portion (total or partial) of the item from the old classification corresponds to the item from the new classification. If the portion is total (T), it means that the entire content of the item from the old revision is associated with the corresponding item from the new revision. If the portion is partial (P), it means that the item from the old revision corresponds to several items from the new revision.[1]

There are several types of associations depending on the complexity of the inter-changes between the items of the two successive revisions. A simple association (type 1:1) matches a single item from the new revision with a single item from the old one. Two other types of associations are also very simple: type merging (several items from the old classification merge into a single item in the new classification, type n:1) and type splitting (one item from the old classification is simply subdivided into several new items in the new classification, type 1:n). Finally, in the case of the complex association (type n:n), several items from the old revision correspond to several items of the new revision.

Let us consider a complex association built for chronic obstructive pulmonary diseases *(Table 1*). According to the established correspondences, the death counts from the items 124 and 125 under the 1965 Classification correspond entirely to the item 108 from the 1970 Classification, *chronic bronchitis, lung emphysema*. The item 130 from the 1965 revision counterbalances items 108 and 113 from the 1970 revision. Checking against the other correspondence table (the 1970 revision *vs.* the 1965 revision), we find that the new item 108 compensates for three old items 124, 125 and 130 with the item

[1] Construction of fundamental associations of items was produced with the help of R function (Pechholdová and Camarda, 2014) and a specially written VBA programme (Bâzgan and Penina, unpublished).

130 linked also the item 113. In this case, a complex association represents a mixture of merging and splitting of several items.

Table 1

Example of a fundamental association #83, type n:n

1970 Classification		Number of deaths		1965 Classification		
#	Title	1969	1970	#	T/P	Title
108	Chronic bronchitis, lung emphysema	2001	1564	124	T	Bronchitis and lung emphysema
			23	125	T	Other and unspecified forms of bronchitis
			814	130	P	Chronic abscessive lung diseases, pneumosclerosis and lung emphysema
113	Chronic forms of pneumonia and bronchiectasis	629	’’	130	P	
85	108, 113	2630	2401			124, 125, 130

** T/P – Deaths counts are transferred from an old item to a new one totally (T) or partially (P)*

Source: Penina, Meslé, Vallin.

After producing the fundamental associations of items based on the correspondence tables, the next step is to check their coherence at the statistical level. For that, for each association we verify if the total of deaths classified under the items of the old classification is roughly the same as the total of deaths classified under the items of the new classification. However, this procedure is not enough since a small difference between the numbers of deaths in 1969 and 1970 may be due to the normal fluctuations of mortality trends. Thus, to ensure the statistical consistency, we studied the annual trends in the numbers of deaths for each fundamental association of items for the period 1965-1980 covered by the 1965 and 1970 revisions of the soviet classification. For most of cases, the changes in the numbers of deaths for 1969 and 1970 corresponded well to the changes in annual trends for the whole of the period. For a few cases, however, the trend does not move smoothly across the classification change, and it means that there is a discrepancy between the theoretical definition of items and coding practices. This is a consequence of improved definitions resulting from the advancement of medical knowledge that often causes complex inter-item exchanges (Meslé and Vallin, 1996). A simple visualization of trends in the numbers of deaths (eye check) is a classical approach used to detect the discontinuities in death time series. Another way provided by Camarda and Pechholdova implies a statistically oriented method based on prediction of the mortality series and user-defined cut-offs according to the level of statistical significance (Camarda and Pechholdová, 2014). However, based on the data for the Baltic countries, it was shown that although this automation procedure provides good indication for detecting the disruptions, it cannot substitute entirely the classical eye check of mortality trends (Meslé and Vallin, 2014). After detecting disruptions in associations, it is then necessary to determine which medical definitions actually correspond to coding practices and to adjust the problematic associations accordingly.

Table 2 displays the distribution of the associations by type with the corresponding death counts constructed for the transition from the 1965 revision to the 1970 revision. Fortunately, 99 of the 141 fundamental associations established between the 1965 and the 1970 revisions are simple and contain 26% of the total of deaths in the transition year. The two categories referring to the fundamental associations assigned as type splitting and merging cover 9% and 14%, respectively. The total number of deaths attributed to these two associations is relatively small (5%). Finally, only 19 fundamental associations were built as complex, but they concentrate the biggest part of the total number of deaths (69%).

Once the statistical continuity of each fundamental association is ensured, at least in terms of the total number of deaths, the next stage involves calculating the transition coefficients that make it possible to move from the items in the old detailed list to those in the new one.

Table 2

Distribution of fundamental associations of items by type and death counts. Transition from the 1965 revision to the 1970 revision of the soviet classification

	1970 Classification			
	Associations		Deaths (in 1970)	
Association type	Number	Proportion, %	Number	Proportion, %
type 1:1	99	70	7014	26
type 1:n	9	6	1019	4
type n:1	14	10	162	1
type n:n	19	14	18399	69
Total	**141**	**100**	**26594**	**100**

Source: Penina, Meslé, Vallin.

Transition coefficients

At the third stage, the associations serve as frameworks within which we estimate, item by item, transition coefficients that will allow us to redistribute the deaths classified according to an old classification among the items of a new one. In the case of simple association (type 1:1), 100% of deaths recorded under the old item are transferred to the new item. The same process is used when several old items are merged to form a single new item (type n:1), which is a simple sum of death counts from each of the old items concerned. In the case of splitting one item into several new ones (type 1:n), the hypothetical distribution of deaths recorded under a single item in the old classification is obtained according to the proportions observed for each of the new items.

The computation of the transition coefficients becomes somewhat more difficult in case of complex interchanges between the items. In many cases, the coefficients can be calculated almost automatically, assuming a proportional distribution of deaths. *Table 3* demonstrates the estimation of the transition coefficients for the items gathered into Association 85 presented already in Table 1. At first, a double-classification cross-table must be constructed (part a, Table 3). We know the distribution of deaths in 1969 across the old items and distribution of deaths in 1970 across the new items. So, we can calculate the hypothetical distribution of deaths in 1970 across the old items according to the proportions observed in 1969. We assume that within the associations the respective proportions of the items do not change between 1969 and 1970. In our example, we attribute 1713 deaths of the total 2630 deaths to item 124, *Bronchitis and lung emphysema*, 25 deaths to item 125, *Other and unspecified forms of bronchitis,* and 892 deaths to item 130, *Chronic abscessive lung diseases, pneumosclerosis and lung emphysema* (the estimated values are shown in italic). Then, we redistribute the deaths inside the cross-table. The shaded areas mean that there is no correspondence between the two items according to the links established in the association and these cells are eliminated. The deaths in non-shaded cells can be redistributed automatically. In our example, the entire contents of the cells classified under items 124 and 125 (1713 and 25 deaths, respectively) is transferred to item 108. Similarly, the 629 deaths under item 113 are transferred to the corresponding cell for item 130. Finally, to fill in the last empty cell for item 130, we simply subtract the known deaths from the deaths observed in 1970 (2001-1713-25=263). The transition coefficients (part b, table 3) are then directly deduced from the completed cross table: 100% of deaths under old items 124 and 125 are to be assigned to new item 108. Deaths recorded under old item 130 are redistributed among new items 108 and 113 according to the following proportions: 29.5% (263/892) and 70.5% (629/892), respectively[1].

[1] Construction of double-classification cross-tables and calculation of transition coefficients were produced with the help of a specially written VBA programme (Bâzgan and Penina, unpublished).

Table 3

Double-classification cross-table to redistribute ex post deaths gathered in Association 85 built between items in 1965 and 1970 classifications, followed by transition coefficients

a)

	1965 Classification			
1970 Classification	124	125	130	
108	*1713*	*25*	*263*	2001
113			*629*	629
Estimated deaths in 1970	*1713*	*25*	*892*	2630
Observed deaths in 1969	1564	23	814	2401

b)

	1965 Classification		
1970 Classification	124	125	130
108	100.0	100.0	29.5
113			70.5

**The estimated numbers are shown in italic.*

Source: Penina, Meslé, Vallin

First, the transition coefficients for 209 items of the 1965 classification have been calculated as described above in terms of total numbers of deaths. Then, for each item, the statistical continuity of the series was checked by age. Since the total annual number of deaths is relatively small in Moldova, this was done only for three main age groups: under one year old, 1-59 years, 60 years and over. In most cases, the results were acceptable and the age and cause-specific time series did not show any major discontinuities at the point of transition; however, for 20 out of 210 items in the 1965 Classification coefficients had to be age-adjusted.

After having reconstructed the 1965-1969 time series by sex and age in terms of the 1970 Classification, they were linked to the crude 1970-1980 data, and we obtained continuous time-series classified under the 1970 Classification for the whole period 1965-1980.

2. Other transitions

The reconstruction method as described for the transition between the 1965 and the 1970 revisions was applied to the subsequent changes in classifications. *Table 4* summarizes the results of the transition by the type of associations with the corresponding numbers of deaths. Here, like for the previous transition, the proportion of associations defined as simple (type 1:1) is the biggest and covers a quarter of all the deaths in 1981. At the same time, the share of the items involved in complex exchange of items (type n:n) between the two classifications is relatively small and covers up to 70% of total deaths. The new items resulted from splitting or merging of the old items occur quite rarely. At this step of reconstruction, transition coefficients for 19 out of 185 items of the 1981 soviet classification were adjusted by age.

In 1988, an important amendment in relation to accidental causes of death was introduced into the 1981 classification. Under the 1981 Classification, every accidental cause of death, with a few exceptions, includes two items referring to occupational and non-occupational accident. In 1988, this division was abolished, and the accidental causes of death with and without this specific distinction were united into a single item. As a result, 160-185 items referring to deaths from injury and poisoning were reclassified into 160-175 items. This amendment led us to produce a reclassification of accidental causes of death by simple merging of the two items from the 1981 Classification into one new item in 1988.

Table 4

Distribution of fundamental associations of items built between the 1970 and the 1981 Classification by type and death counts

	1981 Revision			
	Associations		Deaths (1981)	
Type of associations	Number	Proportion, %	Number	Proportion, %
type 1:1	129	84	10265	25
type 1:n	6	4	1935	5
type n:1	6	4	466	1
type n:n	13	8	28810	69
Total	**154**	**100**	**41476**	**100**

Source: Penina, Meslé, Vallin.

In Moldova, the 9th revision of the International Classification of Diseases and causes of Death (ICD) and the last revision of the soviet classification were used in parallel over the period 1991-1995. While the National Bureau of Statistics (NBS) continued to codify causes of death under the 1988 Classification, the National Centre for Health Management (NCHM) adopted the 9th revision of ICD. Certainly, in this situation, we decided first to redistribute death counts classified under the 1988 Classification among the ICD-9 items, and then to produce the last transition from ICD-9 to ICD-10. It seemed to us reasonable to produce the fundamental associations of items and to calculate the corresponding transition coefficients for 1991 year. To avoid too complex associations of items, these were constructed separately for three age groups: under one year old, 1-59 years and 60 years and over.

Table 5 summarizes the results of the transition from the soviet classification to ICD-9, showing the distribution of fundamental associations with the corresponding total of deaths (under ICD-9[1]) by the type and age. For the three age groups, the biggest part of deaths is concentrated in the complex associations (type n:n), varying from 70% for the age group under one year and 86% for the elderly.

Four-digital ICD-10 items have been tabulated into 211 categories with the medical content similar to 214 categories of ICD-9 items. *Table 6* presents the distribution of associations by type with the corresponding numbers of deaths in 1996. Like in all the previous stages of the reconstruction, though most of the fundamental associations of items belong to a simple type (type 1:1), they include only 35% of the total deaths. Twenty complex associations (type n:n), on the contrary, cover 64% of the total of deaths. The check of statistical continuity by three main age groups did not reveal any important disruptions in death time series, and the same transition coefficients were applied to all age groups.

Table 5

Distribution of fundamental associations of items built between the 1981 Classification modified in 1988 and ICD-9 by three age groups, type and death counts

Type of associations	Under 1 year				1-59 years				60 years and over			
	Associations		Deaths (in 1991)		Association		Deaths (in 1991)		Association		Deaths (in 1991)	
	Number	%	Number	%	Number	%	Number	%	Number	%	Number	%
type 1:1	113	80	353	25	87	71	2320	17	92	74	2152	7
type 1:n	16	11	75	5	11	9	478	3	15	12	1397	5
type n:1	3	2	0	0	1	1	347	3	1	1	630	2
type n:n	9	7	1012	70	24	19	10459	77	16	13	26317	86
Total	**141**	**100**	**1441**	**100**	**123**	**100**	**13605**	**100**	**124**	**100**	**30497**	**100**

Source: Penina, Meslé, Vallin

Table 6

Distribution of fundamental associations of items built between ICD-9 and ICD-10 by type and death counts

Type of associations	**ICD-10**			
	Associations		Deaths (in 1996)	
	Number	Proportion, %	Number	Proportion, %
type 1:1	143	85	17568	35
type 1:n	2	1	424	1
type n:1	4	2	5	0
type n:n	20	12	32062	64
Total	**169**	**100**	**50059**	**100**

Source: Penina, Meslé, Vallin.

Using the method of reconstruction, we obtained the continuous 1965-2012 cause-of-death time series by sex, 5-year age groups and 198 ICD-10 groups of items. However, before moving to their analysis, we had to produce some additional adjustments to remove the discontinuities in time series

[1] The total of deaths under the soviet classification recorded by NBS and ICD-9 recorded by NCHM in 1991 differs slightly (45849 versus 45852, respectively).

resulted from the changes in coding practice not related to the adoption of a new classification and occurred over the inter-revision period.

3. Additional adjustment of the reconstructed time series

In addition to the periodic revisions of the official classification, the changes in coding practice issued to certifying doctors or coders may also interrupt the continuity of statistical series for some causes of death. This type of problem affects all the countries, including the former Soviet republics. Further, we shall discuss about the additional *a posteriori* corrections we produced to diminish such discontinuities and the problem of striking growth in mortality from senility that affected Moldova like other former Soviet republics in the 1990s. This type of correction was produced after every transition from an old classification to a new one, i.e. in four steps. We made the first round of *a posteriori* corrections to the 1965-1980 time series classified under the 1970 classification, and the second one to the 1965-1990 time series classified under the 1988 classification. After the third transition, from 1988 soviet classification to ICD-9, *a posteriori* coefficients of correction were applied to the 1965-1995 statistical series. Finally, the fourth round of this type of corrections was produced after producing the 1965-2012 time series according to ICD-10. For example, the number of deaths classified under the item 85, *Chronic rheumatic heart diseases*, under the 1970 classification decreased abruptly in 1974 year, which was simultaneously accompanied by the symmetric increase in number of deaths attributed to the item 84, *Active rheumatism (Figure 1).* To level this disruption, we transferred 30% of deaths attributed to the items 85 to the item 84 for the period 1965-1973.

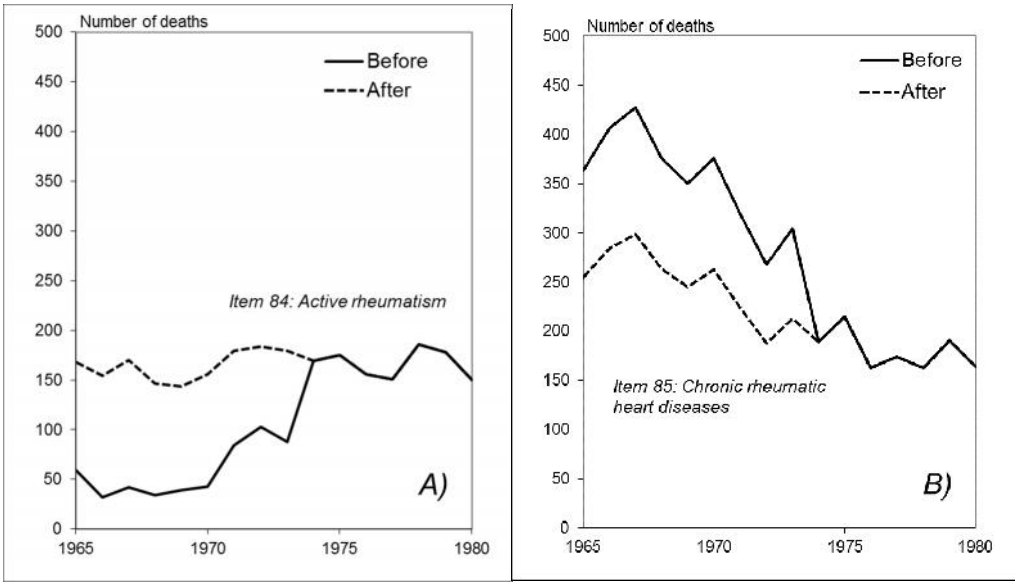

Fig. 1. Annual trends in number of deaths classified under items 84 and 85 according to 1970 soviet classification before (panel A) and after (panel B) *a posteriori* correction, age 1-59 years old, both sexes

Source: Penina, Meslé, Vallin

Conclusions. This paper describes the method of reconstruction of the continuity of death time series under the fixed classification of causes of death for the Moldovan data. Based on this method, we eliminated the breaks in 1965-2012 mortality series for this country provoked by the periodic changes in the classification of causes of death both in the soviet period (three revisions of the soviet classification in 1970, 1981 and 1988) and after the independence (ICD-9 in 1991 and ICD-10 in 1996). Additional *a posteriori* corrections were produced after every transition from an old classification to a new one. A special problem not presented in this paper is the growth of mortality from senility in the 1990s. For Moldova, we adopted a special method of distribution of senility deaths among three groups of diseases of the circulatory system. As a result of our work, we could obtain 1965-2012 death time series by sex and age reconstructed under the 10th revision of International Classification of Diseases and Causes of Death.

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Acknowledgments: The study was supported by *Project AXA Mortality Divergence and Causes of Death*. The author expresses her sincere and deep gratitude to Dr. France Meslé and Prof. Jacques Vallin (INED) for their long-term collaboration and help and Vladimir Bâzgan for his proficient technical assistance.

Recommended for publication: 15.05.2015