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Mortality from ischaemic heart disease in Poland in 1991–1996 estimated by the coding system used since 1997

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Abstract

Background: Official statistical data on deaths due to heart disease and cerebrovascular disease in Poland in 1991–2005 are not consistent because of the changes in the coding system introduced after 1996. Between 1996 and 1999, the number of deaths due to ischaemic heart disease (IHD) increased considerably, while the number of deaths due to atherosclerosis decreased. Considering the magnitude of these changes, any analyses of mortality trends in these periods treating these data as consistent are practically impossible. This also applies to international comparisons of IHD mortality data.

Aim: To develop a method of estimating the number of deaths that would approximate the real numbers of deaths due to IHD in Poland in 1991–2005.

Methods: Sets of individual death records from the Central Statistical Office (CSO) and data from the WHO Mortality Database were used. The IHD mortality data documented officially in Poland were obtained using two different coding systems used consistently before and since 1997. IHD mortality was highly consistent in each of these periods. The applied version of the regression model makes use of both these properties.

Results: The system of certifying death causes which was used in Poland before 1997 resulted in underestimating the real number of IHD deaths in Poland in 1991 by around 35% compared to the numbers estimated using a more correct system of certifying death causes used after 1997. Approximate relative error of the official number of deaths due to IHD in 1991 in age groups of 45–54, 65–74, 75–84, and ≥ 85 years was 30%, 24%, 49% and 67%, respectively, in men, and 27%, 25%, 52% and 72%, respectively, in women.

Conclusions: An increase in the IHD mortality rate in Poland in 1996–1999 noted by CSO was an apparent phenomenon resulting from inaccuracies in coding death causes before 1997. These inaccuracies were mainly related to IHD, atherosclerosis and cerebrovascular disease. Our method enabled correction of the number of deaths between 1991 and 1996, yielding figures much closer to the real ones. Using this method, it is also possible to assess long-term mortality trends, including evaluation of the effectiveness of different methods of treatment and prevention. In particular, it also refers to the use of the IMPACT model to analyse reasons of changes in IHD mortality in Poland.

Key words: mortality, ischaemic heart disease, atherosclerosis, death coding, IMPACT model, Poland

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INTRODUCTION

A decrease in mortality due to cardiovascular diseases (CVD) has been seen in Poland since 1991, contrasting with previous increase in cardiovascular mortality seen in Poland in 1970––1990. This reversal of mortality trends is an interesting phenomenon. It can be observed not only in Poland but also in the majority of other Eastern European countries, and is temporally related to socioeconomic changes that have occurred in this region. Knowledge about exact causes and mechanisms of this decrease in cardiovascular mortality in Poland would be of great practical values as it would allow designing specific actions that might result in a further decrease in mortality.

However, official Polish Central Statistical Office data regarding ischaemic heart disease (IHD) suggest that despite a systematic reduction in number of deaths due to IHD seen in 1991–1996 and 1999–2005, a sharp increase in IHD mortality rate was noted in 1996–1999, especially among the elderly (Fig. 1). At the same time, overall number of deaths due to CVD showed a constant downward trend in 1991–2004.

In this study, in addition to a general overview of our proposed method of estimating number of deaths, we present some arguments suggesting that the increase in IHD mortality rate in 1996–1999 as reflected by official data has been an apparent phenomenon resulting from a change in the way causes of death were coded between two period: until the end of year 1996 and since year 1996.

An exact estimation of the actual trend is particularly necessary to create a mathematical model of coronary artery disease that would allow, for example based on the method developed by Capewell et al. [1], precise quantification of factors related to a decrease in IHD mortality rate seen in Poland in 1991–2005.

Accordingly, the aim of our study was to develop a method of estimating actual number of deaths due to IHD in Poland in 1991–2005 and perform appropriate calculations assuming consistent coding of deaths due to IHD in the study period.

METHODS

Our proposed method of estimating number of deaths due to IHD in 1991–1996 is based on a model similar to an equal slope regression model. Model parameters were estimated using official data on the number of deaths from 12 years, i.e. 1991–1996 and 1999–2004. Data from 1997––1998 were incomplete due to physician protests (in 1998, the cause of death was not given in as much as 1/5 of death certificates) are thus were not taken into account in the present study.

Data from 1999–2004 were interpreted as suffering from random errors, and data from 1991–1996 as suffering also from a constant systematic error. One of the parameters of our model is interpreted as an estimator of a constant systematic relative error in the number of deaths in 1991–1996. The other two or three are parameters of linear or squared time function, respectively, were considered to describe precisely changes in the actual number of deaths throughout years 1991–2004. Further in the description of the algorithm, these interpretations were expressed as respective assumptions based on, among others, the facts given below.

Figure 1. Changes in mortality due to ischaemic heart disease in Poland in 1991–2005. Source: WHO Mortality Database. Dashed vertical line marks the change in the coding system

From the beginning of 1997, death causes are coded in Poland using the 10th Revision of the International Classification of Diseases (ICD 10) that replaced the previous version of this classification (ICD 9). In addition, this coincided with introduction of a different approach to coding by qualified regional coders based on original causes given in death certificates. Before 1997, these causes of death initially given by physicians in death certificates were coded as the final causes of death.

The previously used coding system resulted in atherosclerosis being given as the most common cause of death due to CVD in 1991–1996, amounting to 31% of all coded death causes in 1996. At the same time, coronary artery disease was given as a cause of death in 27% of cases, and cerebrovascular disease in only 13% of cases. With the introduction of a new coding system, these proportions changed significantly (Fig. 2). In 1999–2005, atherosclerosis was coded as a cause of CVD death approximately twice less commonly and amounted to 13–15% of cases.

Changes in mortality in 1991–2004 based on official data, as detailed by Jasiński [2] separately for five causes (cerebrovascular disease, IHD, atherosclerosis, CVD overall, and cancer), both genders and different age subsets (0+, 65+, 35–44, 45–54, 55–64, and 65–74 years), support, in parallel to other arguments, a notion that the observed increase in IHD mortality was an apparent phenomenon mostly or completed related to erroneous coding of many cerebrovascular disease and IHD deaths as deaths due to atherosclerosis that took place before 1997. In this report, this concept is illustrated in Figure 2 as the contribution of deaths due to IHD, cerebrovascular disease and atherosclerosis in the overall CVD deaths.

Analyses of the IHD mortality curves usually indicate (for example, see reports by Jasiński et al. [3, 4] and Kupść et al. [5]) that the functions expressing number of deaths in relation to time in the Polish population (and also its voivodeships) are very regular and may be precisely approximated by linear or squared equations, both for the period before 1997 and the period after 1999.

Our proposed method was used to estimate the number of IHD deaths in 1991–1996 that would be coded as such using the coding system introduced in 1997. Despite the fact that coding in 1999–2005 was also subject to sporadic errors, for simplicity the coding system used during these years was considered correct, and the coding system used in 1991–1996 suffered from a systematic error resulting from a partial departure of the correct coding system.

Below we described the basic algorithm and its simplified version. The simplified algorithm, in contrast to the basic one, is based only on an approximate constancy of respective areas in Figure 2 and the concept of systematic underestimation of the official numbers of deaths due to cerebrova-

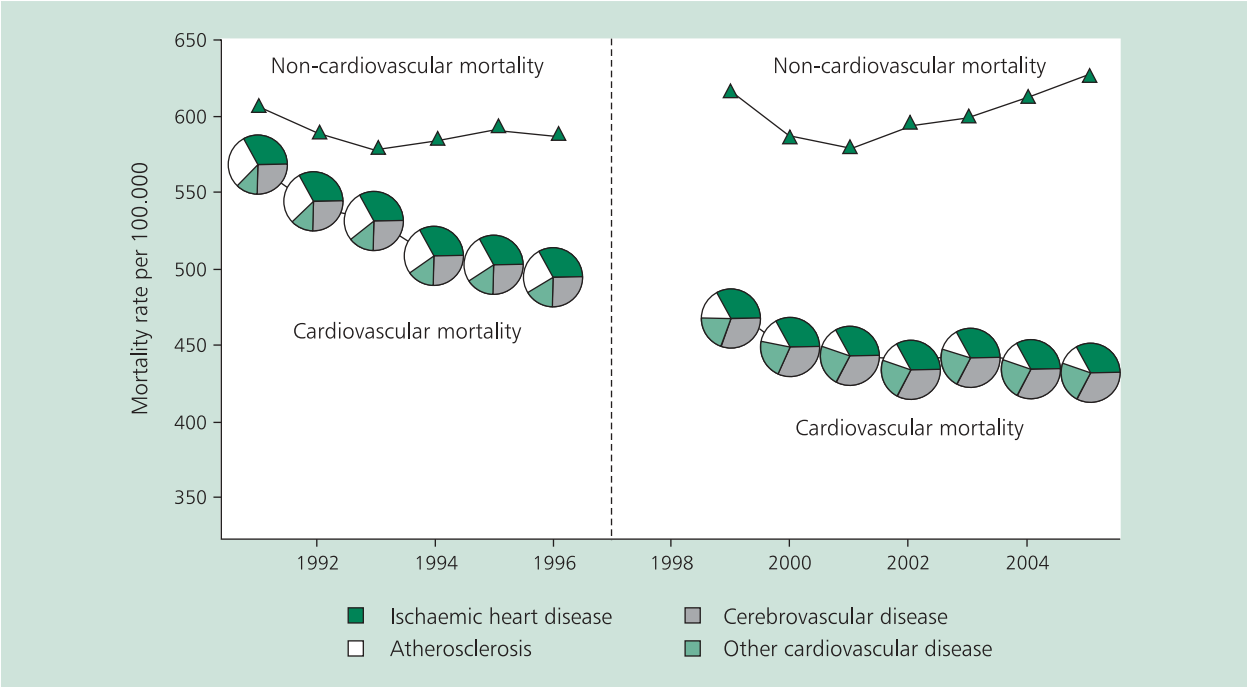

Figure 2. Changes in mortality due to cardiovascular disease and other causes in men in Poland in 1991–2005. A downward trend in cardiovascular mortality is seen throughout this period. However, contribution of specific cardiovascular causes to overall cardiovascular mortality changed after 1997. Dashed vertical line marks the change in the coding system. Source: WHO Mortality Database. Rates are unstandardized

scular disease and IHD in 1991–1996. Correct numbers of deaths (that would be coded using the coding system introduced in 1997) in 1991–1996 and 1999–2004 are marked as *deaths1, ..., deaths6, deaths7, ..., deaths12*.

Description of the basic algorithm

This algorithm is based on an assumption of high reliability of official data, in a sense that in 1991–1996, constant rules of coding the cause of death used by an approximately constant group of coders, regardless of their individual skills, resulted in approximately the same systematic error relative to correct but unknown numbers *deaths1, ..., deaths6*. In contrast, this type of systematic error was negligible in 1999–2004. An additional argument suggesting that the rules of coding the cause of death as IHD in 1991–1996 and 1999–2005 were different but constant in each of these periods is approximate constancy of respective areas in Figure 2.

For the estimation, 12 numbers were used corresponding to the official data from 1991–1996 and 1999–2004. In accordance to the assumed data reliability, these 12 official numbers of death can be expressed as: *g1=deaths1(1+b), ..., g6=deaths6(1+b), deaths7, ..., deaths12*. Thus, estimation of *deaths1, ..., deaths6* only requires obtaining *b'* which is an approximation of an unknown constant *b*.

To obtain *b'*, we used an assumption that sequence {*deaths1, ..., deaths12*} may be approximated with a high precision based on a linear or squared time-dependent function. Finally, *b'* is obtained in parallel to the parameters of a linear or squared time-dependent function. For this purpose, a standard regression procedure was used, similar to an equal slope regression model.

With estimated *b'*, the approximated correct number of deaths in 1991 can be expressed as: $deaths1 = g1/(1+b')$ /1/.

Description of the simplified algorithm

Figure 2 suggests that the contribution of deaths due to IHD to overall CVD mortality separately in 1991–1996 and 1999–2005 may be considered roughly constant in each of these periods. Official numbers of deaths due to CVD changed similarly throughout 1991–2004 and this, together with other arguments, allows a conclusion that these values are closely approximated to the actual values throughout the study period. If, as suggested by Figure 2, the contribution of deaths due to IHD to overall CVD mortality was approximately the same in each of the years 1991–1996 and may be given by *U1*, and the contribution of deaths due to IHD to overall CVD mortality in each of the years 1999–2004 is given by *U2*, then the contribution of deaths due to IHD to overall CVD mortality in years 1991–1996 that would result from the use of 1999–2004 coding system also equals *U2*. Thus, the estimating formula may be simplified to $deaths1 = g1 * U2/U1$. In other words, $1/(1+b)$ from the equation 1 may be simplified to *U2/U1*.

The various approaches we used to estimate *deaths1* together with error analyses are subject of a separate mathematical discussion that will be published in a dedicated journal. However, it is worth noting that differences between the results obtained using different estimation approaches turned out to be minor.

RESULTS

Based on the values given in Table 1, the relative error of the official number of deaths due to IHD in 1991 in age subsets of 45–54, 65–74, 75–84, and ≥ 85 years was 30%, 24%, 49% and 67%, respectively, in men, and 27%, 25%, 52% and 72%, respectively, in women. The use of pre-1997 coding system resulted in an underestimation of the official number of deaths due to IHD in 1991 by approximately 35% compared to the current coding system used since 1997.

DISCUSSION

As already mentioned, estimation of number of deaths due to various causes in 1991–1996 according to the current coding system used since 1997 allows uniform evaluation of

Table 1. Comparison of the number of deaths due to IHD in Poland in 1991 and 2005 (for 1991 official and estimated data are presented)

	Year	Age groups							Total
		25–34	35–44	45–54	55–64	65–74	75–84	≥ 85	
Men									
Official number of deaths	1991	400	2528	4392	8856	7822	4593	817	29 408
Corrected number of deaths	1991	416	3286	6237	10 158	10 335	8956	2467	41 855
Official number of deaths	2005	69	577	3238	4985	7612	7807	2723	27 011
Women									
Official number of deaths	1991	57	415	850	2502	4470	4726	1414	14 434
Corrected number of dearhs	1991	57	573	1165	2502	5945	9925	5048	25 215
Official number of deaths	2005	19	90	576	1356	4221	9679	6815	22 756

actual numbers of deaths due to various cardiovascular causes before and after introduction of ICD 10 coding. As data regarding numbers of deaths after 1997 may be considered reasonably precise, an effective method of estimating number of deaths due to various causes in 1991–1996 according to the current coding system used since 1997 is a necessary prerequisite for any meaningful comparisons of data on death causes before and after 1997. Otherwise, such comparisons would lead to inappropriate conclusions. This is important both for evaluation of changes in risk factors in the population and for effective prevention and treatment of coronary artery disease. Such data are necessary for any long-term analyses regarding trends in IHD mortality in Poland, performance of meaningful international comparisons, and the evaluation of healthcare policy.

The register of deaths in Poland is administered by the Central Statistical Office. These statistics are based on so-called statistical cards for the death certificate, filled by physicians or other healthcare personnel authorised to issue death certificates (e.g. medical assistants, midwives and nurses). However, a vast majority of death certificates is currently issued by physicians (approximately 99.6% of death certificates in 1996; source: *Rocznik Demograficzny* GUS 2008).

Until 1996, the physician issuing the death certificate stated the cause of death and coded it using the ICD 9 coding system. In 1997, three major changes were introduced: death causes began to be coded using the ICD 10 coding, three-digit codes were replaced with more accurate four-digit codes, and a central system of coding was introduced at the voivodeship level, with a dedicated group of physicians specially trained to code death causes. Since 1997, the physician issuing the death certificate only states the cause of death, and then this cause is verified by a coding physician who assigns an ICD 10 code to be recorded in the register of deaths administered by the Central Statistical Office (Wojtyniak and Goryński [6]).

These changes in the coding system introduced in 1997 had a significant effect on the quality of national data regarding causes of death. Of note, both ICD 9 and ICD 10 coding systems are unequivocal in regard to IHD, and thus these changes mainly resulted from two reasons: acutely restricted use of the code for atherosclerosis as the cause of death in the ICD 10 coding system and introduction of the voivodeship-level coding physicians.

It is clear that these unexpected but pronounced changes in the structure of CVD mortality after 1996 (compared to the early 1990s) are an apparent phenomenon related to changes in coding atherosclerosis as a cause of death. No other plausible explanation can be offered for such a large increase in the number of IHD and cerebrovascular deaths within one or even 3 years, especially when seen mainly in only some age subsets. Similarly, no other explanation can be offered for the large decrease of deaths due to atherosclerosis. Analyses of trends in CVD mortality published by the Institute of Cardiology clearly confirm a systematic decrease in number of IHD deaths seen in 1991–1996 and 1997–2005 (Kupść et al. [5], Jasiński et al. [3, 4]).

This problem was previously analysed in a study by Wojtyniak and Goryński [6] who examined causes of CVD mortality in 12 "old" voivodeships in 1996–1998. This study showed an unusually large apparent decrease in mortality due to atherosclerosis in 1997–1998 (by about 50%) that could be attributed to inappropriately common use of this code for death cause until 1996. At the same time, large apparent increase in deaths due to IHD (by about 50%) and cerebrovascular disease was noted.

Difficulties with evaluation of real changes in numbers of deaths due to particular forms of CVD related to changes in the coding system (ICD 9 *vs* ICD 10) we also reported in other countries including Australia, Belgium, United States, Germany and Japan [7–12]. These classification errors also hamper meaningful comparisons of IHD mortality between various countries [13]. In 2001, an algorithm was published that gave more comparable estimates of mortality for various countries (Lozano [14]). Unlike our considerations, corrections in a study by Ford et al. [9] were relevant to only a minor percentage of values taken into account. Careful analyses of WHO Mortality Database performed by one of the authors show that in none of countries with available data on atherosclerosis as the cause of death in 1991–2005 (overall 72 countries), differences in the structure of deaths due to particular forms of CVD were as pronounced as in our country (Fig. 3). Previously, greater mortality due to atherosclerosis was reported only in the former German Democratic Republic (Fig. 3).

Many experts note that death registries, even if systematically improved, are not an ideal source of information for the population health analyses [7, 8, 13]. A percentage of deaths coded as of unknown or uncertain cause is still quite large in many countries. Also in Poland, until 1996 the quality of national data regarding causes of death was sometimes questionable, especially in some parts of the country (Rywik et al. [15], Wojtyniak and Goryński [6]).

Regardless of current shortcomings, continuously improved registries of mortality data in particular countries or regions remain a fundamental source of information about population health status, used by WHO experts, governments and medical and scientific communities.

Our proposed method to estimate the number of IHD deaths before 1997 that would be coded using as such the coding system introduced in 1997 allowed effective correction of official data from years prior to 1997, suffering from a large systematic error. Our analyses based on various approaches to mathematical correction of official mortality data show that in 1991, the actual number of IHD deaths was underestimated by about 23,000, and if more correct coding system introduced after 1996 were used at that time, this number would be close to 67,000.

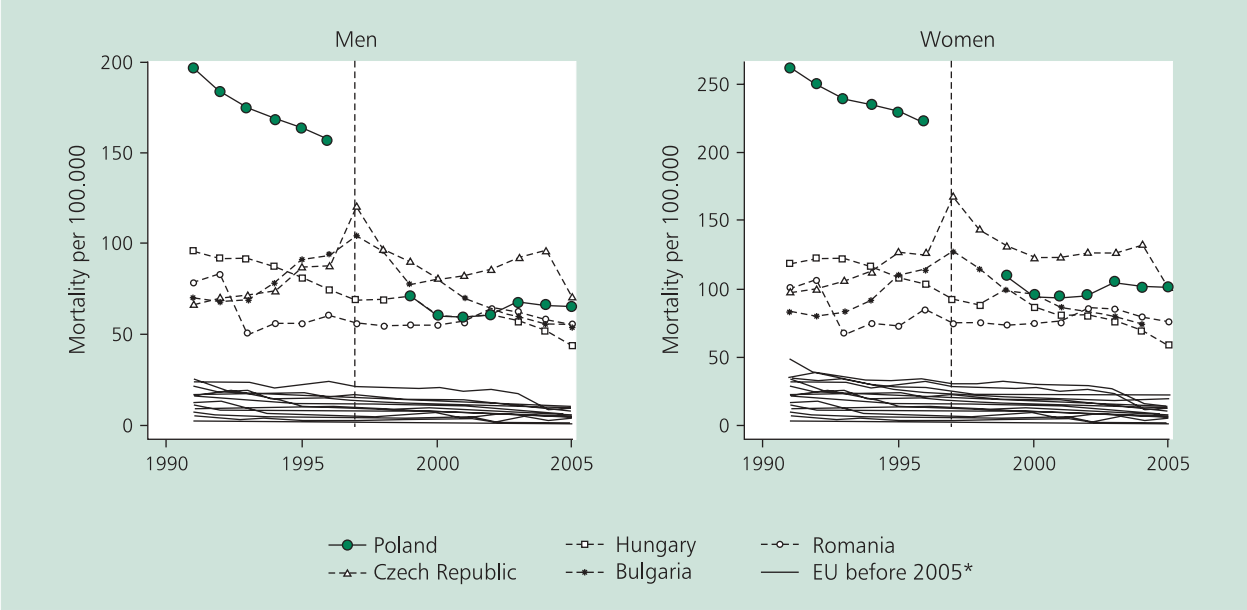

Figure 3. Official data regarding mortality due to atherosclerosis in Poland and selected European countries. Source: WHO Mortality Database. Dashed vertical line marks the change in the coding system; *European Union members before 2005

Corrected data on IHD mortality in 1991–1996, with data for 1991 presented in Table 1, may be used e.g. to implement the IMPACT model (Capewell et al. [1]) for Poland, and also in all analyses and publications regarding changes in IHD mortality before and after 1997.

Detailed mathematical explanation and discussion of various variants of the presented approach is beyond the scope of this publication but was presented by one of the authors during scientific mathematician and biostatistician meetings. As noted in "Methods", a paper will be published describing theoretical justification and comparisons of precision of estimating number of deaths with the use of various selected mathematical models.

Of final note, many arguments suggest that also in 1999––2004 and later years some deaths due to IHD and cerebrovascular disease are still coded as due to atherosclerosis (code I70), although the ICD 10 coding system prohibits the use of this code for deaths due to IHD or cerebrovascular disease (see Wojtynik and Goryński [16]). However, this does not affect the quality of our estimations regarding the number of deaths due to IHD in 1991–1996 that would be coded as such using the coding system introduced in 1997.

CONCLUSIONS

1. The increase in number of death due to IHD in Poland in 1996–1999 was an apparent phenomenon resulting from changes in coding system introduced in 1997.
2. The use of pre-1997 coding system resulted in an underestimation of the official number of deaths due to IHD in 1991 by approximately 35% compared to the current coding system used since 1997.

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Oszacowanie liczby zgonów z powodu choroby niedokrwiennej serca w Polsce w latach 1991–1996 w sposób odpowiadający zasadom kodowania stosowanym od 1997 roku

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Streszczenie

Wstęp: Oficjalne dane statystyczne (GUS) dotyczące zgonów z powodu chorób serca i naczyń w Polsce w latach 1991–2005 są niejednolite. Jest to wynik zmian w sposobie klasyfikacji przyczyn zgonów wprowadzonej po 1996 roku. Szczególnie dotyczy to miażdżycy i choroby niedokrwiennej serca (ChNS). W latach 1996–1999 zaobserwowano w przypadku ChNS duży wzrost liczby zgonów wśród osób z ChNS i jednocześnie duży spadek liczby zgonów wśród pacjentów z miażdżycą. Dlatego wszelkie analizy trendów umieralności dla okresów obejmujących lata 1996–1999 (także międzynarodowe porównywanie umieralności z powodu ChNS) traktujące oficjalne dane jako poprawne są praktycznie niemożliwe. Sposób rozwiązania tego problemu dodatkowo utrudnia brak części rozpoznań dla lat 1997 i 1998 (strajki lekarzy).

Cel: Celem pracy było opracowanie i zastosowanie metody oszacowania zbliżonych do rzeczywistych liczb zgonów z powodu ChNS w Polsce w latach 1991–2005.

Metody: Materiał obejmował zbiory indywidualnych danych na temat zgonów, przekazywane corocznie przez Główny Urząd Statystyczny oraz WHO *Mortality Database*. Metoda opiera się na wykorzystaniu regularności zmian w umieralności spowodowanej ChNS w Polsce. Dzięki temu w celu estymacji liczb zgonów z lat 1991–1996 można stosować uogólniony algorytm regresji jednakowych nachyleń.

Wyniki: Stosowany w Polsce przed 1997 rokiem system klasyfikacji przyczyn zgonów spowodował zaniżenie rzeczywistej liczby zgonów z powodu ChNS w Polsce w 1991 roku o około 35% w stosunku do liczb, które odpowiadają oszacowaniom według bardziej poprawnego systemu kodowania przyczyn zgonów, stosowanego po 1997 roku. Dla grup wiekowych: 45–54, 65–74,75–84 i ≥ 85 lat przybliżony błąd względny oficjalnych liczb zgonów z powodu ChNS w 1991 roku wynosił dla mężczyzn odpowiednio: 30%, 24%, 49% i 67%, zaś dla kobiet: 27%, 25%, 52% i 72%.

Wnioski: Wzrost umieralności z powodu ChNS w Polsce w latach 1996–1999 wynikający z oficjalnych danych (GUS) dla Polski był zjawiskiem pozornym, wynikającym z niedoskonałości w sposobie kodowania przyczyn zgonu w Polsce przed 1997 rokiem. Niedoskonałości te dotyczyły głównie ChNS, miażdżycy oraz chorób naczyń mózgowych. Zastosowana metoda pozwala na taką weryfikację liczb zgonów dla lat 1991–1996, która umożliwia bliską stanowi rzeczywistemu ocenę długofalowych trendów umieralności w Polsce, a w rezultacie także na ocenę skuteczności różnych metod prewencji i leczenia. W szczególności dotyczy to zastosowania modelu IMPACT w celu analizy przyczyn zmian umieralności z powodu ChNS w Polsce.

Słowa kluczowe: umieralność, choroba niedokrwienna serca, miażdżyca, klasyfikacja przyczyn zgonów, model IMPACT, Polska

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